

**U.S. DEPARTMENT OF COMMERCE
National Technical Information Service**

PB-279 077

**The Preparation of Fuels and Feedstocks from
Municipal Solid Waste. Proceedings of a Workshop
Held at New Orleans, Louisiana on February 8-10, 1977**

Franklin Associates, Ltd, Prairie Village, Kans.

Prepared for

Municipal Environmental Research Lab, Cincinnati, Ohio

Dec 77

EPA-600/9-77-034

PB 279 077

December 1977

**THE PREPARATION OF
FUELS AND FEEDSTOCKS FROM
MUNICIPAL SOLID WASTE**

**Municipal Environmental Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268**

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/9-77-034		2.	3. RECIPIENT'S ACCESSION NO. PB279077
4. TITLE AND SUBTITLE THE PREPARATION OF FUELS AND FEEDSTOCKS FROM MUNICIPAL SOLID WASTE		5. REPORT DATE December 1977 (Issuing Date)	
7. AUTHOR(S) Marjorie A. Franklin, Editor		6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Franklin Associates, Ltd. 8340 Mission Road Prairie Village, Kansas 66206		8. PERFORMING ORGANIZATION REPORT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS Municipal Environmental Research Laboratory--Cin., OH Office of Research and Development U.S. Environmental Protection Agency Cincinnati, Ohio 45268		10. PROGRAM ELEMENT NO. EHE624C	
		11. CONTRACT/GRANT NO. CA-7-2431-A	
15. SUPPLEMENTARY NOTES Proceedings of U.S. EPA Workshop held at the Braniff Place Hotel, New Orleans, Louisiana, on February 8-10, 1977		13. TYPE OF REPORT AND PERIOD COVERED Final	
16. ABSTRACT This report is a record of the proceedings from a workshop held in New Orleans, Louisiana, on February 8-10, 1977, among a group of experts in the field of processing municipal solid waste into useable fuels and other recyclable materials. The body of the report consists of a verbatim discussion among meeting participants. These sections were transcribed from the tape-recorded meeting sessions. In addition, a summary of all discussions and conclusions is included. The report serves as a comprehensive, up to date, state-of-the-art summary for municipal solid waste processing technology which should be useful to designers and researchers in the field of solid waste management.		14. SPONSORING AGENCY CODE EPA/600/14	
17. KEY WORDS AND DOCUMENT ANALYSIS			
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Waste Disposal Waste Treatment Natural Resources Processing Circulation Recovery	Solid Waste Processing Resource Recovery Shredding Components Separation Recycling	13 B	
18. DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (This Report) unclassified	21. NO. OF PAGES 243	
	20. SECURITY CLASS (This page) unclassified	22. PRICE PC A11 MFA01	

THE PREPARATION OF FUELS AND FEEDSTOCKS
FROM MUNICIPAL SOLID WASTE

Proceedings of a Workshop held at
The Braniff Place Hotel, New Orleans, Louisiana
February 8-10, 1977, and Sponsored by the
U.S. Environmental Protection Agency
Solid and Hazardous Waste Research Division and by
Technology Transfer

Edited by Marjorie A. Franklin
Franklin Associates, Ltd.
Prairie Village, Kansas 66206

Project Officer

Donald A. Oberacker
Solid and Hazardous Waste Research Division
Municipal Environmental Research Laboratory
Cincinnati, Ohio 45268

MUNICIPAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

DISCLAIMER

This report has been reviewed by the Municipal Environmental Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This report is intended to record the proceedings from a workshop in which important matters relating to solid waste processing were discussed. Attending the workshop were a large number of people who represented the nation's leading expertise in the field of converting solid waste from the as-produced state into useable fuels and feedstocks for recycling. It is anticipated that each comment, conclusion, and recommendation by these experts from government, industry, and the public sector will be of immense value to anyone planning or engaged in the selection, research and development, design, or procurement of such equipment and systems.

Francis T. Mayo
Director
Municipal Environmental Research Laboratory

PREFACE

Municipal solid wastes (MSW) contain almost everything imaginable in terms of materials and resources which could, but for the correct technology, be recycled or used again for a good purpose. Much of the wastes is burnable, therefore some of the first uses explored have been to use MSW as a fuel for heating and/or other power needs. For the non-burnable fractions of MSW, it has been recognized that these portions are rich in metals and glass. The iron, steel, aluminum, brass, and other metals can be separated out and reused. The glass can also be reused with a net benefit to all concerned.

All of the above mentioned recycling schemes are dependent upon finding the right processing and handling technology to effect the desired separation steps or to produce the right form of the end products. The disciplines of engineering, science, and economics are heavily involved. Above all, the environmental effects must be carefully watched so that man does not further pollute the environment while in the process of saving valuable materials or energy from this waste stream which is otherwise destined to be disposed of by burial or incineration.

This report should help shed light on a number of possible processing techniques whereby recycling might occur. The technology discussed is the latest "state-of-the-art" available, as presented by some of the leading professionals and experts currently working in this field of interest.

ABSTRACT

This report is a record of the proceedings from a workshop held in New Orleans, Louisiana on February 8-10, 1977, among a group of experts in the field of processing municipal solid waste into useable fuels and other recyclable materials. The body of the report consists of a verbatim discussion among meeting participants. These sections were transcribed from the tape-recorded meeting sessions. In addition, a summary of all discussions and conclusions is included. The report serves as a comprehensive, up to date, state-of-the-art summary for municipal solid waste processing technology which should be useful to designers and researchers in the field of solid waste management.

CONTENTS

	<u>Page</u>
Disclaimer	ii
Foreword	iii
Preface	iv
Abstract	v
Contents	vii
Acknowledgement	viii
 SUMMARY	 1
 VERBATIM TRANSCRIPT	 31
 SESSION 1: SYSTEMS PROCESS DESIGN	 33
Moderator: Dr. Albert J. Klee, U.S. Environmental Protection Agency	
 SESSION 2: SELECTION OF EQUIPMENT	 70
Moderator: Stephen Lingle, U.S. Environmental Protection Agency	
 SESSION 3: TECHNICAL OBSTACLES	 130
Moderator: Dr. Harvey Alter, National Center for Resource Recovery	
 SESSION 4: APPROACH TO R/D&D PROGRAMS	 174
Moderator: John Burckle, U.S. Environmental Protection Agency	
 SESSION 5: SUMMARY AND CONCLUSIONS	 207
Moderator: David Berg, U.S. Environmental Protection Agency	
 APPENDIX A - Agenda	 224
 APPENDIX B - Participants	 228

Preceding page blank

ACKNOWLEDGEMENT

The author, on behalf of the U.S. Environmental Protection Agency, wishes to express his appreciation for all of the efforts made by the entire group of people who participated in the development of this report.

In particular, Mr. John O. Burckle and Dr. Albert J. Klee who originated and implemented the workshop; Mr. Carlton C. Wiles who devoted considerable efforts toward its success; Dr. James E. Smith Jr for the conference accommodations and organization; and finally all of the participants who contributed so much are to be acknowledged.

Mrs. Marjorie A. Franklin of Franklin Associates and her secretary Mrs. Shari Brown performed exceedingly well on the difficult task of technical interpretation, transcribing, summarizing and typing the manuscript. Mr. Steven C. Lees of EPA, co-op student from the University of Cincinnati, handled the job of overall coordination and management of EPA's requirements, editorial changes, and final proof reading with professional skill.

Finally, Mr. Herbert I. Hollander is commended for his thorough efforts in reviewing and commenting on the entire volume of transcribed dialog, not just his own meeting contributions.

THE PREPARATION OF FUELS AND FEEDSTOCKS FROM MUNICIPAL SOLID WASTE

SUMMARY

The workshop on preprocessing and preparation of fuels and feedstocks from solid waste was called to order by John Burckle of the Municipal Environmental Research Laboratories, Office of Research and Development, USEPA. He introduced David Berg, Office of Energy and Minerals Industry, Office of Research and Development, USEPA, who gave the opening remarks. Berg explained that the purpose of the workshop was to bring together people most involved in resource recovery--architects/engineers, cities, government agencies, and companies--to talk together. He mentioned that the Office of Solid Waste and ORD had cooperated on the meeting because of their interest in solid waste. EPA is looking for mechanisms to facilitate debate, discussion, and resolution of issues in solid waste. Berg outlined the agenda: Session 1, System Process Design; Session 2, Selection of Equipment; Session 3, Technical Obstacles; Session 4, Approach to R/D&D Programs; and Session 5, Summary and Conclusions. He mentioned the site visit to Recovery 1 scheduled for February 10.

SESSION 1: SYSTEM PROCESS DESIGN

Dr. Albert J. Klee moderated Session 1. He outlined two objectives for the session. The first was to determine what information on preprocessing is wanted or needed by those involved to select a system given the equipment available today, and what information is needed to design more efficient systems than those available today. The second objective was to identify the critical aspects of design in the area.

Information Needs

A strong theme running throughout the session (and other sessions as well) was the lack of information available to designers, manufacturers, and users of the equipment and systems. Harvey Alter described it that there was no state of the art recorded. On numerous occasions members spoke for or against the desirability or even possibility of writing a handbook or "cookbook."

The discussion on information began when Dave Bendersky presented a summary of a report by Midwest Research Institute on the state of the art of preprocessing. MRI had interviewed three groups--system designers, manufacturers, and users/operators. All of these groups agreed on the need for more data. The designers need information on equipment and arrangement alternatives, how the equipment actually works on municipal solid waste, and cost effectiveness data. The manufacturers need in-

formation on actual operating conditions and an exchange of information between manufacturers and system designers and users. Bendersky remarked that adequate data in the open literature is not now available, just personal exchange of information. The users are not instructed how to operate new plants efficiently, and must learn from experience.

Bendersky and Alter stressed the need for good planning before making tests in a plant. Bendersky mentioned that the ultimate purpose of the data should be determined before testing to avoid getting random information. Alter suggested determining the format and range of parameters before taking data. Bendersky said that we should develop tests with commonality, so that we can evolve comparative data from different plants.

It was generally agreed that the withholding of proprietary information by private companies is a serious impediment to the flow of information. Those speaking on this point included Floyd Hasselriis, Dave Spencer, Steve Lingle, Art Purcell, Tom Lamb, and Peter Ware. Hasselriis felt that a possible solution is to use government facilities, such as the Bureau of Mines, to test fuels and get standardized information which can be compared with other fuels such as coal. Lingle pointed out that private companies are reluctant to let a government contractor come into their facilities for the purpose of collecting data. Spencer suggested that a solution is for the government to fund basic unit operation development and demonstration programs, with the results available to all. He felt this would be more economical than the various industries spending development money over and over. Hollander suggested developing data-gathering programs and installing monitoring equipment at all the full-size operating plants being installed in the public sector, i.e., Chicago and Rochester. Any new facility should incorporate a Federally-funded data-gathering system.

With regard to feedback of information from users to manufacturers, some members felt that manufacturers do not actively seek this information on their equipment. Speaking of their experience on this point were Dr. George Trezek and Bill Ryder. Ryder felt that this sort of thing fell into the category of R&D and competition being what it is today, in order to keep prices down manufacturers are reluctant to expend money for research on a piece of equipment once it has been built.

Bob Powers said that since manufacturers do not make information on their equipment available, it is up to the plant operators to make the equipment work. He felt there can never be a "cookbook" plant because a plant must be designed for local conditions.

Hollander felt that operating instructions were not possible for a new plant, but guides should be developed as operation is experienced. Unfortunately, experience is not always passed on to new people coming into the plant, therefore a concerted "on-going" orientation and training program should have high priority.

Speaking about proprietary information, Ware said that since Occidental's plant is partially funded by the government, all testing there would become public knowledge. He felt that rather than losing their competitive edge, Occidental would benefit from the publicity.

Dr. Greg Rigo felt that you should not shut down a plant while collecting data. Spencer felt that testing an operation would always disturb the operation.

Modeling of Alternative Systems

Rigo described a modular design which his firm had used to simulate performance. He said that everything cannot be accounted for, and the results depend on the quality of the data going in. Rigo felt that with good models and good planning, data collected can be used to validate models. Otherwise a great deal of data can be collected, but have no value.

Burckle stated that there could never be a standard plant, but the principles of equipment models, unit operation models, and systems models could give optional alternatives.

Sequencing of Unit Operations

The discussion of sequencing was opened by Alter, who said that designers now follow the sequencing of existing plants. He suggested that instead they should look at their objectives first, then sequence unit operations accordingly. Later Alter suggested comparing different operational sequences on paper by writing down the performance of the various components, then determining product quality to see if it meets specifications.

Ware said that in Occidental's experience, their process and end specifications were already known. They visited other plants, then designed their sequence to make the feedstock for pyrolysis.

Lamb commented that there is no one right answer on sequencing. Spencer felt that unit operations must be evaluated before systems are evaluated.

Materials Handling

Early in the session, Alter stated that materials handling is an important problem. He contrasted the cleanliness of European plants with the dust and other hazards of many plants here. Bendersky agreed that materials handling has been ignored.

Ware described a method they had used where air was circulated back into the shredder to eliminate dust. A vacuum system was applied to the shredder.

Scale-up

Considerable attention was given to scale-up of pilot plants and whether testing could best be done in pilot plants or full-scale operating plants.

Roger De Cesare stated that a first plant is always a pilot plant whatever its size. He felt that there must be flexibility in the design of a plant to take care of unforeseen things that happen. Different problems arise from scale-up of a pilot plant; therefore design is empirical. Trezek felt it important to use a realistic scale in testing.

During the discussion of testing at full-scale, Bendersky stated that full-scale testing can obtain some data, but other data requires special test facilities. Ryder felt that testing on a full-scale plant is more productive because the problems associated with a L&B Model or pilot plant differ radically from those in the full-scale plant and stated that "the mere act of increasing the size changes the problem." Ryder also felt that Federal grants should include any expense of downtime during testing.

There was some discussion of testing unit operations rather than systems. Rigo thought that someone (probably the Federal government) should build a pilot plant so controlled experiments could be run on unit operations. Spencer saw a need to test operations rather than build a pilot plant.

Quantity/Composition of Raw Refuse

Much debate was generated over the need for data on quantity and/or composition of the waste stream. Hollander and Don Walter felt it important to know what is going into a system in order to design properly. Hollander pointed out that the cellulosic and mineral fractions are needed to do the economics. Burckle agreed that composition is important to economics.

It was generally agreed, as Arnold Chantland pointed out, that there is great variability in the incoming material. Alter suggested that a system should be designed for a bandwidth on composition, and that the contractual tip fee should be readjusted based on operating experience.

Dr. A. W. Joensen stated that it is very expensive to look at composition going into the system. He suggested looking at each piece of equipment within a range of composition, and designing subsystems.

Lamb stated that quantity of waste is much more important than composition, since composition varies day-to-day. He said the quantity to be delivered is important for a contract with a community. He felt that the economics should not be dependent on a certain mineral fraction.

Specifications and Requirements of Fuel

Lingle asked how much processing is necessary to produce a marketable RDF. Rigo felt that the fuel should be as poor quality as would be acceptable, thus saving processing costs. Hollander pointed out that coal has been used for years, yet it varies greatly in quality.

C. W. Fay disagreed with the "poor quality" idea, stating that another utility failure would hurt the industry. He said the utilities don't want to take the risks. The fuel should be tailored for the customer.

Hasselriis pointed out that the industry had gone from an unprocessed fuel burned on a grate to a dry powder fuel which is more uniform than coal. He said that processing equipment must be designed to accommodate a plus-or-minus 25 percent variation, or more, in any particular characteristic or constituent. The variability of the final fuel or other final product depends on the amount and effectiveness of the processing done.

F. E. Wisely observed that the quality of the refuse-derived fuel was more a function of the potential fuel user than of some predetermined standard. Some users specify a high degree of refinement of the fuel; others are far less demanding. In the interest of practicality, some compromise often is necessary.

Walter suggested that it is a mistake to assume the utility is the best customer for RDF. The utilities have long-term contracts for low cost fuel, and they are conservative. On the other hand, the smaller industrial boilers with spreader stokers have higher fuel costs now, and are less conservative. There are also more potential customers among the industrial boilers. Hasselriis agreed with this point. Hollander pointed out that the industrials are being considered low priority fuel users and have limited leverage in obtaining fuels.

SESSION 2: SELECTION OF EQUIPMENT

The moderator, Stephan Lingle, opened the session by breaking unit operations into materials handling, separation, and size reduction. He listed numerous topics as possibilities for discussion. The moderator then called on Dave Bendersky of Midwest Research Institute, who presented a summary of a report prepared by MRI. The report lists 12 pre-processing equipment categories. Bendersky said they found research needs in all categories. Shredders have received the most research attention, but many questions are still unanswered. Full-scale operating experience is not generally reported in the literature; people are getting experience on their own. Bendersky discussed shredder problems such as maintenance schedules, safety, and operating costs. In areas other than shredders even less is known, and experience is not reported in the literature. Process control and dust control are not covered at all.

Materials Handling

General. It was generally agreed that more research and exchange of information is needed. Dr. Harvey Alter mentioned the problems of materials bridging and hanging up. He said we learn through a process of art, and experiences are not recorded. Steve Hathaway pointed out that a theory of design and flow for flow and storage facilities was developed at the University of Utah in the 1950s. However, this is known by very few. Hathaway felt that research is needed on the mechanical properties of RDF.

Harvey Funk felt there are better ways of storage and retrieving than those in use now. He felt research could identify conversion processes and feed rates. New systems could be compared to the Atlas systems in use. Funk thought a design handbook would be of benefit, and noted that a few manufacturers have published handbooks.

Bob Powers felt a problem is that the equipment is not designed for garbage handling but is borrowed from other industries. He felt that manufacturers should design specifically for the refuse processing. Bendersky noted that industry does not get the information needed to improve equipment design. He suggested a conference of users and manufacturers to exchange information.

Atlas Storage Systems. The moderator stimulated much discussion by suggesting that the Atlas storage system is not working. He mentioned Baltimore where, perhaps because of material size, the material has solidified, and there have been wear problems on the floor.

Arnold Chantland said that the Atlas system is not a total failure. He said the system will handle material less than 2 inches, but will not handle larger material. To prevent spontaneous combustion and Btu loss, the bins should be emptied once a week.

Funk also felt that the Atlas system does work, but he said it is a high energy user. He said the problem of floor wear can be handled in design. Funk felt the Atlas system is still the best available.

F. E. Wisely stated that the Atlas bin should be used as a distributor, not for storage. He also felt the Atlas is the best available now. Wisely mentioned that vehicles can be used for storage up to a certain point.

At Chicago, Bill Ryder said the City of Chicago ended up with two Atlas bins as a result of preparing specifications for competitive bidding. The system has not yet been tried with refuse. They do have a performance specification the contractor must meet.

Dr. A. W. Joensen mentioned that an Atlas bin sweats inside and that therefore ice may form. This can be avoided by running unused conveyors every three or four days. Joensen said a mass weighing system for control purposes into the boiler should be part of a storage and retrieval system. He recommended a belt system using the Atlas bin.

Conveyors. Peter Ware described the Occidental system. Refuse is received on the floor from trucks. It is fed into the shredder, then conveyed to the floor of the building. The shredded refuse can be stored on the floor for up to 8 weeks with no problems. A front end loader then feeds the refuse into a doffing roll bin; it then goes to the air classifier. He felt the doffing roll bin is very effective and the capital cost is about half that of an equivalent Atlas bin.

A number of problems with conveyors were discussed. Tom Lamb mentioned spillage and belt cleaning. He said MSW does not flow--diverge, not converge. Alter described problems in the NCRP pilot plant when they first had self-cleaning head pulleys on all conveyors but even these sometimes get clogged. There is some now-obscure relation between the nature of what is clogging and the size of the pulley. When the material is like gravel, it "dances." Rags hang-up everywhere. Design of materials handling equipment for a resource recovery plant is often a process of trial and error and it is important to record experiences if others are to learn.

Another problem described by Dr. Greg Rigo was that a dry load of material would not go up an inclined conveyor. At one installation they sprayed the material with water to make it go up. Rigo stated that compositional differences must be accounted for.

Wisely recounted an experience at St. Louis, where a vibrating conveyor was put in a pit. The frequency was a direct multiple of the building height, and the problem was accentuated by the pit.

Chantland mentioned the dust problem caused by the drop of material from one conveyor to another. Lamb added that you will find dust at every transfer point. To control dust at Ames, Chantland used a pneumatic system. Replaceable liners were used at the elbows to solve the wear problem. To solve the wear problem on air lock feeders, replaceable blades are used.

Size Reduction

Investigations at Berkeley. Dr. George Trezek showed slides and described his investigations on shredders for EPA. He said that about 1969 shredders were designed for brittle materials. Since refuse is about 25 percent brittle, further investigation was needed. He first investigated existing machines, then set up a machine at the University to run controlled experiments.

The equipment includes a Gruendler hammermill modified to operate at variable speeds. Feed rates on the conveyors can also be varied. The equipment also includes an air classifier.

Trezek stated the subject of investigation is: Given an input size distribution, can the output size distribution be predicted for a particular set of conditions, using a heterogeneous material like solid waste. He summarized two theories of size reduction. The continuous theory works for brittle materials. The discontinuous theory, which Trezek used, is a statistical treatment. He also described a breakage function and a selection function. The breakage function describes how material is broken according to size distribution. The selection function describes the fraction of material selected to be broken during a given task.

Trezek showed slides summarizing the relationships developed in his work. He correlated energy consumption and other parameters such as speed and moisture content with size distribution. One can therefore determine how energy savings might be obtained. Given the product size distribution, the model can predict primary, secondary, and tertiary grinding. The results show that running the machine at lower speeds produces less wear of the hammers. Trezek measured size distribution of all components of the waste stream and looked at system arrangement of shredders, screens, etc. Energy expenditures were plotted to obtain a characteristic size with various arrangements. Moisture in the waste stream can also be related to energy content.

Alter described work where they had looked at particle size distributions of material from 10 shredders around the country. They found that the PSD fit the Rosin-Rammler distribution. They also found that the Bond Work Index is within about plus or minus 20 percent of 400 for all shredders. If this value is verified, then the relationship between power input and particle size can be predicted for shredders.

Alter also mentioned that the hammers in the secondary shredder operating on air classifier light fraction did not shred textiles well enough to avoid plugging the d-RDF pellet mill. When the hammers in this vertical shredder were replaced with rotor blades and stator blades, the textiles were cut. Alter said that their work generally agreed with the results described by Trezek.

Trezek added that the next stage of his work will be to look at wear characteristics versus particle size distribution.

Moisture Loss. Following Trezek's presentation, there was some discussion of moisture loss through the shredder. Floyd Hasselriis pointed out that in Trezek's test the moisture range was 15 percent up. He said that at lower moisture content, the material is very tough and hard to pull apart, then suddenly it becomes brittle.

Doug Fiscus observed that the moisture loss through the shredder is apparently about 6 percent, and this must be accounted for in the economic model of a plant. Roger De Cesare said that the moisture loss in the Bureau of Mines pilot plant is 10 percent (including air classification and shredding). Herb Hollander said that under certain atmospheric conditions the moisture released in a shredder can actually be seen as a vapor plume leaving the shredder dust cyclone (i.e., St. Louis).

Hasselriis stated that the horsepower into a mill heats the material, then dries it. Alter ended the discussion on moisture loss by observing that moisture is not evenly distributed in refuse, therefore a moisture balance is meaningless.

Other Research Needs. There was some general discussion of other research needs in the size reduction area. Lamb felt that types of size reduction other than shredders should be explored. He reported success with ball mills. Ware asked why we shred and stated it was for convenience of storing and handling. He felt that detailed research is fine for optimization, but this can come later. Ware observed that shredders have vast differences in performance for the same horsepower, and would like to know why. Alter said that we do not really understand size reduction, and therefore we have no basis for invention. He suggested that a sizing circuit to achieve a homogeneous material may be a good approach.

Rigo observed that power surges through the shredder must be accounted for in design. He also suggested presegregating wood items, which could be put into a secondary shredder rather than primary size reduction. This would avoid losing the heating value of the wood.

The topic was concluded with a discussion of size reduction for small-scale operations. Hollander observed that size reduction goes back many years, and shredders in most early waste processing installations were too small. Rigo felt that not much was now available for small-scale operations. Alter disagreed, saying the flail mill works well at 5 tons per hour. The large items can be picked out first. Rigo said you can use a trommel pre-breaker to "open up" the refuse bags. He suggested using a magnetometer to stop the feed conveyor if something massive comes through, to minimize damage.

Separation

General. There was general agreement that sufficient information on separation is not available. Alter and Bendersky spoke on the need for a sharing of information among those having operating experience. Alter said we need orderly experiments in existing plants and to make comparative measurements on the same basis. Lingle said that we don't want to vary parameters in existing plants and need separate research facilities.

De Cesare felt there is a need for basic research on unit operations, while Ryder saw a need for basic research to improve systems. Lamb suggested setting up a matrix of data-defining variables such as particle size and moisture content. He felt the research should test unit operations, not define systems. People can optimize their own systems. Dave Spencer suggested that since testing is very expensive, it should be done properly or not at all.

Hathaway and Rigo spoke on the need for classification for small systems. They noted that military waste is different from civilian waste, however, so research there may not help others.

Rigo pointed out two problems in air classifier research. The first is the basic fundamentals of how an air classifier works. The second is research on the performance of specific equipment. Rigo felt the government should not do the latter.

Tuning of Systems. There was some discussion of tuning the equipment. Bendersky said that individual companies tune their equipment and should make the information available to others. Spencer observed that tuning equipment depends on the material to be put in and performance therefore varies. Peter Cambourelis added that it also depends on the fuel requirements of the customer. John Burckle felt that rangeability of the fuel is not so wide and a tune point is needed.

C. W. Fay felt a need for flexibility in design so changes can be made as the waste stream changes. He said there could be trouble in the future if we fine tune for conditions today.

Hasselriis pointed out that an air classifier is not a simple device; different functions take place inside, each of which may take separate tuning to get the desired result. He felt we need fundamental research on the unit operations inside the device.

Types of Separation. Some members of the workshop described specific types of separation. Hasselriis said that magnetic separation needs a second step, similar to winnowing, to separate other materials that go along with the magnetics.

Don Walter described the use of a drum conveyor which takes a first cut of the magnetic material, then a second magnetic belt conveyor separates the light from the heavy ferrous fraction.

Alter described the use of a ballistic drum at Warren Spring, England, to separate food waste by bouncing the light material.

Process Control

The moderator outlined some areas of interest: Dust control, explosion control, and fire control. He mentioned problems at early solid waste plants.

Dust Control. Hasselriis said that it is necessary to draw air through shredders, since they act as fans, and to keep the shredder outlets under negative pressure to prevent dust and lint from blowing throughout the building. When enclosing the air system, fire hazards can be reduced by recirculation of air, and maintaining fairly high levels of water vapor. A Fenwal rate-of-rise sensor can detect the fast pressure buildup associated with fires.

Lamb observed that equipment is available to control dust. He felt information is needed on the properties of dust. Safety is noncontroversial, he said, and people should be willing to share experiences. Safety standards need to be set.

Hathaway said they have done some testing on the properties of dust, and it is both highly fibrous and highly volatile. It would be desirable to reinject the dust into the fuel production process because of its volatility.

The health implications of dust were discussed at some length. It was agreed that this is a highly sensitive area. Chantland said that limited research only creates a problem in the mind of the public, without really answering the questions. Hasselriis observed that the investigation creates the problem by suggestion, and therefore we must be very careful in investigation.

Trezek said they have done health research in their laboratory, but have only scratched the surface. Alter described the program at NCRR's pilot plant. Employees are given an annual physical exam, and are instructed to report any job-related illnesses. He said if others would do the same, information could be pooled. NCRR is also doing dust sampling. Alter also told the group that ASTM Subcommittee E 38.07 was working on standards in the health area. This is a sub-committee of the Resource Recovery Committee E 38.

Walter said it would be necessary to extend health investigations to include garbage collectors. Bendersky remarked that New York City has done this. The findings generally were that the garbage collector is not a greater health risk from respiratory diseases than other street service people.

Lamb told the group that puncture injuries can be prevented with steel soled safety shoes.

Explosion Control. Alter said that a design manual on explosion prevention is needed, but Bendersky felt that shredder manufacturers do not have the information to produce a manual.

Ryder described the experience in Chicago. They had a shredder with a Fenwal system for explosions and a sprinkler system to hold down dust. Ryder felt that they had avoided an explosion in over 5 years of operation because of this. However, last year a partially filled tank of acetylene gas found its way into the stream and caused an explosion which damaged the conveyor at the bottom of the shredder, the side wall of the building, and relief vents on the roof. Contributing to the damage was the fact that the relief vents had been sealed tight as they had been leaking water. Ryder felt that it was impossible to prevent explosions when items of this nature get into the refuse stream.

Ware said that they expect explosions at their plant. They have designed their feed hopper so it goes straight through the roof; therefore an explosion will blow through the roof. They keep the shredder isolated to prevent injuries from detonations. They do not use a Fenwal system.

Fire Control. Ware said that steam can be used for snuffing fires if it is available. However, water will produce steam, giving the same effect.

SESSION 3: TECHNICAL OBSTACLES

John Burckle opened the session by saying that he hoped to hear about technical obstacles from the perspectives of the public sector, the architects/engineers, and the consultants. This would help the Federal government to direct their resources in R&D. Dr. Harvey Alter, moderator, outlined three areas for discussion: judgment and risk assessment, development of a research agenda, and who might do the research.

Information and Research Needs

Dr. Alter first asked for comments on information needs from representatives of municipalities, A&E firms, and the military.

Municipal Viewpoint. Richard Bush, representing Connecticut Resources Recovery, mentioned scale-up problems, location of equipment, defining the operation of individual items of equipment, sizing of systems, composition and quantity of material recovered, and trommel operation as areas of interest to him.

Ron Lalka of Los Angeles County said he was looking for: 1) reliability to take all refuse delivered; 2) environmental acceptability; and 3) economics.

Economics. Economics was a subject of interest to many. Dr. Greg Rigo stated that without good accounting systems, you cannot pull out reliability and cost information. Dave Bendersky pointed out that present accounting systems vary greatly, and you cannot now generally tell what it costs to operate any one piece of equipment. He said that there must be some standardization if comparative analysis is to be done. Arnold Chantland of the City of Ames felt that economics is the uppermost consideration. Dr. Alter said that NCRP is developing an accounting manual for Recovery 1, and would be glad to share. Steve Lingle pointed out that EPA has an accounting guide, which probably should be made more detailed.

Duplicate Lines. Chantland brought up the idea of having duplicate lines to provide continuity of operation and avoid the cost of downtime. Bill Ryder of Chicago agreed with the need for duplicate lines to meet the commitment of fuel to the utility. He gave the example of the EPA shutting down an incinerator in Chicago, which lacked air pollution control devices. As a consequence, the City's new RDF plant must have the capability and reliability to make up for the plant which had been shut down. Ryder stated that in the quest for a reliable RDF plant, it should not be forgotten that one of the primary purposes of an RDF plant is disposal of refuse. This is insured with a standby line. However, should the utility be unable to receive the refuse for any reason, a compactor will be provided in the City's RDF plant so that the refuse, shredded or not shredded, can be trucked to another disposal site. Ryder also mentioned that if more fuel could be sold, the redundancy would be needed.

F. E. Wisely commented that whether duplicate lines are economical depends on local circumstances. They cannot be justified for some small facilities. He also said you must have alternate disposal. Steve Levy used the example of Franklin, Ohio, where they have not had to divert waste because they have front end and intermediate surge storage to use if the plant is down. He said you can oversize the parts of the plant you know are going to be down more often. Wisely replied that that system is adequate for a small system, but not for a large one.

Monroe County Experience. Dave Spencer described the Monroe County plant experience concerning storage and redundant lines. He said they have storage for one day's feed in the tipping area. The plant can operate as a transfer station to the landfill if the power lines are down. They have intermediate storage bins to allow time to fix problems, and also have bypasses to remove feed to the landfill. They have additional machinery to densify material for handling if they have to move it by truck. Also they have redundant processing lines. Spencer said a problem in doing reliability availability analysis is sufficient unit operations information. They looked at lead times on spare parts and repair times to determine inventory policies. Spencer felt that the government should not spend money on availability reliability analysis because it is system oriented.

A&E Viewpoint. Harvey Funk opened this part of the discussion with a comment that it is difficult to find something that has been demonstrated when evaluating equipment. He said that developers of systems may not be willing to sell an individual piece of equipment. Peter Cambourelis responded that at the time Funk was looking for an air classifier, Raytheon did not have anything. He said it takes time to develop a demonstrated product.

Performance Specifications and Bonds. The discussion initiated by the A&Es turned mainly to writing performance versus hardware specifications, and requiring a performance bond from the vendor. Wisely thought that a specification should be a combination of good performance and hardware, otherwise it is impossible to evaluate on a comparative basis. The spec may allow alternates, but must attempt to define hardware.

Floyd Hasselriis said that if a contractor takes total responsibility to design, build and operate the plant, he can accept equipment which has a limited guarantee and which may not have been fully proven beforehand, and make it work. He suggested allowing for substantial retrofit or improvement in the project budget, a practice not readily permitted by municipal bidding procedures.

Peter Ware described Occidental's situation. They are a private developer but also have government money, so must go to the low bidder. He has found a spectrum of response from manufacturers. Some will make their equipment work, others have no interest. Ware suggested looking at the responsiveness of manufacturers as well as their other qualities. They have performance guarantees, but cannot always enforce them. In answer to a question, Ware said they did not have performance bonds, but retain a percentage of the purchase price.

Ryder was asked about performance bonds at Chicago. He said that in addition to a performance bond for the full value of the contract, they hold back 10 percent of payment until the equipment is accepted. They also have liquidated damages for late delivery.

There was some discussion of whether requiring a performance bond adds to the project cost. Ryder felt it must add something, but believed that a lot of grief was eliminated because a lot of vendors would not wish to bid with this sort of a threat hanging over their head.

Tom Lamb stated that performance guarantees are good if they can be effected. However, the owner cannot afford to lose money while he waits for a manufacturer to make his equipment work, therefore the owner must sometimes take action himself. Lamb said that the equipment manufacturer cannot afford to take on large liabilities for the sake of a sale.

Spencer described the liability system for Monroe County. The owner selected a system manager to provide professional services, rather than a turnkey or full service contractor. The system manager will buy service on a non-competitive basis, given design and construction management, and 5 years of operation. After 5 years the owner could bid operations to other people. The Monroe County system is similar to that of the Bureau of Mines, although unit operations are sometimes different. Raytheon gave a performance guarantee for the total system and will market the output products to specific specs. They will enter into long-term agreements with buyers and guarantee to meet product specs. Raytheon passed the specs on to the equipment manufacturers. They wrote performance as well as hardware specs. Each vendor is only responsible for his own unit operation or subsystem, and has complete liability for his equipment to the extent of the purchase price. Raytheon assumes the liquidated damages, except for a few equipment items which assume a reasonable share.

Dr. Alter observed that the performance guarantee is a way of dumping the entire R&D responsibility on the equipment vendors.

Military Viewpoint. Steve Hurley felt that he must look at getting fuel with the least investment in equipment. He asked what can people do, what can machines do?

Captain R. F. Olfenbuttel stated the military is looking for the lowest capital investment: this means source separation. However, they may have to use alternatives. He felt they are faced with a lack of information on what to do.

Full-scale vs. Unit Operation Testing. There was much discussion on the usefulness of full-scale testing versus unit operations research. The discussion also touched on full-scale testing versus the pilot plant approach. A general consensus was not achieved.

Lalka stated that he wanted to look at information from full-scale operating plants. He felt that the feedstock at pilot plants is sometimes synthesized. Alter disagreed, saying that the Bureau of Mines, NCRR, and George Trezek all use real refuse. Lalka replied that every city has different refuse, and we should look at operations around the country. Commenting on Lalka's remarks, Burckle said we must deal with the factor of scale because not all communities are the same size. Site specificity also must be dealt with. He asked if we should look at a band width.

In another comment, Burckle suggested that a designer first draws a process diagram and sets the performance needed from each unit operation to get the desired quantity and amount of fuel. The designer then fills in the blocks with specific equipment. Arlie Capps agreed with Burckle on the systems approach.

Speaking on unit operations research, Bendersky felt we should do work on air classifiers, etc., similar to that done by Trezek on shredders. By controlling variables basic information can be gathered. Trezek remarked that his next work would be on densifiers.

Alter said that to understand a unit operation, orderly change is made and related to changes in performance. This makes it almost impossible to make such investigations in an operating plant. For example, NCRR is building an air classifier which can easily be changed for research. The changes - and their investigation - take time, hence are not the sort of thing to be done in a production facility. Alter suggested a spectrum of research, from the university to occasional measurements in a plant. NCRR falls in between.

Rigo said there is a need for a statistical description of waste and a statistical description of unit operations. He suggested looking at new unit operations not now applied. He said the laboratory can be used to get the shape of a curve, then field testing can get data points to validate.

Lamb saw a need for fundamental research on a unit operations basis. If the basic data is available, the designer can select the pieces to optimize his plant. Burckle pointed out that the performance of a unit operation depends on the feedstock. He felt the need to look at complete subsystems. Lamb replied that we can test individual pieces and predict subsystem performance. Whether done all at once or by pieces, the basic design data is still lacking. Spencer agreed with the latter point.

Lingle summarized by stating a need for a whole range of data collection. First, we should gather data on the overall performance of total plants, total systems. This would be of interest to the municipal sector. Second, we need research on unit operations. This would be of interest to the design engineer. Third, we need test procedures at a pilot plant to get really basic data. This also would benefit design engineers. Fourth, we need to develop new equipment. Lingle emphasized that different data is useful to different people.

Design Handbook. Repeating remarks of previous sessions, a design handbook was again discussed. Roger De Cesare mentioned the Taggart book on mineral dressing, which is based on tests of operating machinery. He suggested EPA could have a mobile research lab to get similar data for shredders. Fay felt that shredder manufacturers might not let EPA test and publish data. Spencer also wanted a handbook like Taggart with operating information on various equipment, i.e., energy requirements, replacement parts. Spencer said we are not even starting to obtain this information; it is not in the research budget.

Other Needs. Some other research needs were touched upon throughout the session. Rigo suggested looking at source segregation. Harry Freeman felt that was outside the scope of the meeting. Rigo said that with good unit operation data, solving the mixed waste problem will give a data base to solve the segregated waste problem. Alter said that the decision whether or not to institute source separation in a city is often a political one.

Hasselriis said that Trezek's mathematical model method is very powerful for interpreting test data on our equipment, and to evaluate the potential for improvement.

Again there was some discussion on compositional data. Alter said compositional data only gives one point in the year. We must have the ability to adjust a processing plant to changes in composition. Lamb said compositional data is useless because of daily variations.

Harry Freeman asked if we just need better information on what we have; are we drawing the lines too narrow? Hurley replied that the Navy is trying to apply what's available. Freeman wanted to look at research, not just evaluation of existing equipment. Don Walter agreed that we should develop new equipment for the solid waste feed source, not only use existing equipment. Wisely also felt we should look at equipment that may have potential for the future. He said we have been trying to get our information too precise. We need ranges of information for various parameters.

Capps suggested setting up a field test laboratory to define R&D problems.

Setting Priorities. In order to set priorities on research needs, the moderator asked the group to turn to the list of research needs prepared by Midwest Research Institute, and to choose five items of highest priority and five that should not be investigated. Some members felt the list was restricted to existing equipment, so Alter suggested that other priorities could be added.

During Session 5, Dave Berg made a preliminary report on the results of the voting. Receiving high priority votes were:

General

- Determine Optimal Arrangement(s) of Unit Equipment
- Study Emissions from Processing Equipment
- Determine Effects of MSW Characteristics on Processing
- Evaluate Other Potentially Applicable Equipment

Shredders

Compare the Performance of Various Types of Shredders

Screens

Determine the Effects of Pretrommeling

Economics

Develop Effective Accounting Method(s)

Determine Equipment Operating and Maintenance Costs

Receiving low priority votes were:

General

Determine Effects of MSW Characteristics on Processing

Magnetic Separators

Determine Effect of Magnetic Separation

Dryers

Determine the Effect of Drying on Bacteria and Virus

Evaluate the Effect of Drying on the Combustion Characteristics of RDF

Receiving Facilities

Evaluate Receiving Facilities

Evaluate MSW Segregation Prior to Processing

Ad Hoc Committees

The moderator suggested that workshop members should indicate their interest in serving on committees to develop methods of evaluating unit processes. Four areas were suggested: size reduction, separation, materials handling, and drying.

A great deal of discussion ensued. Chantland suggested the need for a matrix of boundaries to work within. Hasselriis felt the matrix would provide a framework which information could put in, even if it were proprietary.

Doug Fiscus called for a standard method of investigation: 1) the methods have to be fairly specific; 2) the methods must be minimum or base line and leave room for unusual occurrences.

Berg and Lingle suggested adding process control to the list, but Alter said methods of evaluation were already available for process control.

There was a good deal of discussion on how to treat economics. Bendersky suggested a separate economics group. Walter said economics is really a part of each category, and Bendersky accepted that idea. Lingle objected that that would mean economics would be done five times; it would be better to do it all at once. Dan Keyes felt that you could not divorce economic and technical problems. Lalka said the A&Es would be interested in design information, and the municipalities in economics. Burckle said we need a standard economic analysis for the overall plant and also a measurement methodology for each unit operation, which would feed into the total analysis.

Alter again mentioned a design handbook. It should discuss the manner in which data are taken. We need to use the same range of parameters so data will be comparable.

Rigo said that the problem of intensity of data is critical. Alter felt each subcommittee should handle this. He also said while the groups would evolve the matrix, each individual investigator would judge how much data to take. Alter also described the ASTM recommended practice, where an exact format is followed. He indicated the groups might work toward that.

Burckle said we were talking about a commonality in taking measurements, which an ASTM committee is working on now.

(During Session 5, Alter said he had had some discussions with other members of the workshop, and had concluded that the ASME and ASTM provided a suitable way to continue committee activity. He suggested workshop members use the existing committees rather than form new ad hoc committees. This seemed to be the consensus of the group.)

Technical Obstacles

Toward the end of the session, the group listed some technical obstacles, as opposed to social, institutional, marketing, and economic obstacles.

Chantland mentioned whether everyone can use the end product. For instance, oil or gas boilers have to be retrofitted to use RDF. Cambourelis agreed.

Capps mentioned the concern over air pollution in California. This caused people to go to things like pyrolysis, which is yet unproved. Trezek added that boilers in California are not equipped with ash handling equipment, and therefore cannot take RDF.

There was considerable discussion about use of RDF in industrial boilers versus utility boilers. Rigo saw a shift from gas and oil fired industrial boilers to coal and solid fuel, at least in the Mid West. He said new construction could be tailored for RDF. Lingle said EPA has looked at industrial boilers. Nationally their total fuel use is one-half that of utilities. Their average capacity is 30 tons per day of RDF. Only 50 existing industrial boilers could handle the output from a 500 ton per day plant. This means multiple contracts for industrial boilers, which is not as stable financially as a single utility contract.

Herb Hollander pointed out that since the energy crisis, oddly enough, very few new industrial coal fired boilers have been contracted. It will not happen overnight. A community would have to find several industrial users for RDF, as opposed to a utility which signs a long-term contract. However, it is the non-utility fuel users who have the greatest need for a new local fuel source. Since they cannot realistically commit to long-term fuel supply contracts, and only require relatively modest quantities of fuel, they do not have the leverage to command fuel supply.

Wisely said that industries which are really good markets for RDF have a rather constant year-round plant factor. Most industries are seasonal in their steam demand. The industries must have financial incentives to use RDF, although there are other incentives such as being a good neighbor and the environmental image.

Cambourelis said the utilities must make money. They have a unique position as a buyer, because they are organizationally stable. He said we must find a way to make RDF economically attractive to the utility, and perhaps Federal tax incentives might make it worthwhile.

Fay suggested that the resource recovery plant should produce something like pyrolysis oil that anyone can use and get a good price for.

SESSION 4: APPROACH TO R/D&D PROGRAMS

John Burckle, moderator, summarized various strategies for R&D: pilot plant, testing existing systems in the field, testing subsystems on a demonstration scale, and full-scale demonstration. He asked members of the workshop to pay particular attention to scale as they discussed.

Scale-up Problems

Ron Lalka opened the discussion on scale-up by mentioning Monsanto's scale-up from a small pilot plant to a 1,000 ton per day plant. This was a tremendously large scale-up, and he felt it more realistic to do less. Lalka said that Union Carbide is going to a concept of 350 ton modules, which can serve small communities as well as large. He felt efforts should go in that direction. Lalka felt that data from one pyrolysis system might not be applicable to another.

Burckle asked at what scale can research data be used in plant design? Steve Lingle felt the scale depends on the objective, whether you are trying to prove a system or develop design information on a component. Don Walter agreed that it depends on the situation. Any research program must work in an orderly manner to a full-scale demonstration. There is no given answer on how much you can scale up. Walter said that the real problem is that the operator makes a full-scale plant work, but the information does not flow back to the designer.

Herb Hollander commented that equipment suppliers look at the market size and the size of unit with the greatest sales potential. He said a plant made up of modules would give the greatest flexibility. Hollander asked what is scale-up to commercial size? Later he asked what is the smallest commercial size plant that should be tested? Hollander asked Arnold Chantland if he would have put in equipment of less capacity at Ames if he knew the flow rate would be less. Chantland replied that he would not, because of the severe abuse caused by the material. Hollander then asked if a test program should be on equipment of the size at Ames. Chantland said yes. Hollander remarked that a program must be on-going to get both peaks and valleys, and Chantland said that he agreed with testing of units within a process. Burckle asked whether this testing should be on existing plants or a large scale test facility, and Chantland said either. He suggested establishing parameters and ranges.

Bill Ryder stated that once a full-scale plant is built, it becomes the pilot plant for the next generation of plants, and therefore there should be no need to construct another pilot plant. Peter Ware replied that a pilot plant would make the next big plants better. Ryder said that after a large plant gets on-line he would evaluate it for possible improvements before building another plant exactly the same way. Burckle said you could tune a big plant to optimum performance, but not determine if a different sequence of operations would be better. Ryder replied that he would be trying different things in his plant, and make on-going improvements wherever possible.

G. C. Chisamore remarked that scale-up also goes on in other industries, such as pulp and paper. Lalka, however, said that the chemical or pulp industry works with a particular feed material, while solid waste changes every day. He felt that is why a small-scale pilot plant cannot easily be scaled up. Spencer felt that information from a system below 30 to 50 tons per hour might not be applicable to a larger system.

Dave Bendersky said that we do not have systematic data to show what equipment is scalable. The Baltimore experience showed that certain things are not. Dr. Harvey Alter felt that we can learn from the minerals processing industry. He said that screens, froth flotation cells, and trommels can be scaled.

In defense of pilot plants, Dr. George Trezek said they give a feeling for what to measure. Also they give flexibility to change things and try new ideas. Spencer added that you have to go to the next step after the small-scale plant. Dr. Greg Rigo said that hopefully the larger scale is a validation of pilot scale data.

Sampling

Another major topic of discussion was sampling. Bill Parker of Recovery 1 remarked that it is easy to sample in a small-scale pilot plant, but in a large plant built for profit, it is difficult to sample unit processes or systems without perturbing the process. He asked for others' experience on how large a sample should be and where to take it. He felt the best data would be from large plants, but it's hard to get and expensive. Parker said he needs testing to draw up maintenance manuals and set limits of acceptable performance. Ted Sjoberg said you have to evaluate data within a time frame because of variations in the stream. Batch sampling will not give the desired information. Parker agreed.

Speaking of their plans at Americology, Sjoberg said they will evaluate efficiency on a weight basis and set up bookkeeping to evaluate maintenance downtime relative to performance downtime and costs. Parker agreed that an accounting manual is vital to determine the operating effectiveness of the plant. They are working on a manual now, and designing it to pull data out. However, the accounting manual does not see when aluminum, glass, etc., are not meeting specifications.

Sjoberg said they will be sampling material every day to determine the quality of the aluminum, glass, steel, and RDF. Their revenues depend on quality.

Rigo said that at the Landgard plant, they are looking at outfalls and hope to be able to "walk back" into the process. They will establish relationships, and when a relationship changes, it will mean something has gone wrong. Parker pointed out that going back from an outfall point is difficult because you soon reach a common point. Rigo agreed that it is a research problem, but felt that the relationships can be used as a warning system.

There was some discussion of sampling fuel. C. W. Fay said Wisconsin Electric will do sampling of fuel in their own laboratory. Over a year's time they will arrive at a variation agreement with Americology. The one-year testing program is written into the contract.

Pilot Plant Operations

Burckle then introduced various speakers who summarized operations at pilot plant facilities.

NCRR. Dr. Alter showed slides and described the NCRR pilot plant in the District of Columbia. The building is leased at no cost from the District in return for maintenance. The waste is received on the floor and pushed with a front end loader into a conveyor pit. It then goes to a Williams shredder. The shredder refuse discharge goes to a Triple/S air classifier. The air classifier light fraction goes through a blower and is pneumatically conveyed to the incinerator pit, where it is disposed, or it goes to the d-RDF module. The heavy fraction goes past an Eriez belt magnet to a magnetic head pulley, then through a trommel. The minus 2 inch goes to a glass recovery module, the plus 4 inch is rejected as waste, and the 4 x 2 inch middling goes to a CPC eddy current separator. The Al Mag product is collected on the side. Dr. Alter mentioned that much of the equipment is loaned to the Center.

Dr. Alter said that the problem of blowback at the shredder was solved by hooding the input conveyor, so that it keeps coming back in through the shredder. The Triple/S air classifier will be replaced by a vibratory feeder to the research air classifier mentioned in an earlier session. In answer to a question Dr. Alter said that evaluating air classifier performance depends on your objective. One air classifier may be fine for maximizing yield of fuel; for other applications, you may want to maximize quality of fuel.

The Al Mag product contains aluminum cans, foil, and some other material. It needs to be cleaned up to meet reasonable specifications. The product is sent to a prototype air knife, followed by a vacuum hood. They have been experimenting with the blowers to first suck off the organics, then blow off cans and foil from diecast. They have been able to produce Alcoa Grade 1 can scrap. In other tests they have found city-to-city differences.

Dr. Alter then described glass recovery. The minus 1/2 inch goes from the trommel to a screen, then on a conveyor to a jig. From the jig the glass goes to an impact mill, where it is crushed to minus 20 mesh. The slurry is pumped to the froth float arrangement. They have dispersion float followed by a rougher. The product goes into a spiral classifier and the gangue goes to a settling tank. The glass is dried.

The light fraction is de-entrained and pneumatically conveyed to a Heil secondary shredder, then to a surge feeder and pellet mill densifier. Dr. Alter described some bridging problems with the cyclone, where the light fraction hung up at the bottom. They built their own configuration that did not hang up. Also, a hood was added to the Heil shredder, and some air is removed and the dust recirculated. They found that at first the hammers would not reduce the textiles, which jammed the densifier. The hammers have been replaced with rotors and stators. The material is shredded to 3/4 inch. Some textiles still accumulate at the bottom of the machine; these are cleaned out each morning.

In answer to a question, Dr. Alter said that most of their equipment is commercial size. The trommel is undersized because of space constraints.

Dr. Alter then described the densifier. It is a 30-inch die with about 1300 one-inch holes. The pellets are extruded through the die. He described some problems. The machine has to be started very slowly or it jams. They will try another diameter rotor to try to avoid jamming.

Dr. Alter mentioned the large amount of maintenance required in a plant of this sort. It is time and money consuming.

Bureau of Mines. The Bureau of Mines pilot plant was shown and described by Roger De Cesare. Their program began in 1965. Early research centered on municipal incinerator residue, and the residue proved amenable to conventional mineral dressing techniques. The pilot plant has been operating since 1969, using conventional off-the-shelf equipment. As the number of municipal incinerators decreased, the Bureau began to work on separating fractions from raw municipal wastes.

At the pilot plant, material larger than 2 foot is picked, smaller is processed. A flail mill efficiently breaks open bags of refuse. Massive pieces do not damage the flail mill. The mill required an exhaust hood, so this was utilized as an air classifier to remove about 25 percent of the light fraction. They use a series of air classifiers developed by the Bureau.

De Cesare briefly described the early incinerator residue plant. It uses a wet process, with washing, screening, and shredding operations. Magnetic separation is used, and nonferrous metals are concentrated on a screen. Aluminum is separated from copper/brass with heavy media or by jigging.

De Cesare then described the raw refuse plant in some detail. Most of the machinery is scaled for 5 tons per hour, although the flail mill is larger. Material goes from the air classifier mentioned earlier to a magnetic separator, where they get only around two percent paper. The material then goes through an air stream, where lights go into a cyclone. Heavy nonferrous items drop into a trough. There is a medium fraction--rags, cardboard, glass, aluminum, wood, food, etc.--which is put through a trommel. Glass is removed through 3/4 inch holes. The organics in the glass are

separated by jiggling. The ceramic and stone are removed by a froth flotation process, so that mixed glass cullet is removed. Material larger than 3/4 inch passes from the trommel through a secondary shredder and into the third air classifier, a three-stage aspirator. This classifier is tuned to drop out aluminum cans. They are recovering 95 percent of the can stock and 90 percent of the foil. The heavies from the three-stage aspirator are dried and put through an electrostatic separator. They are also testing Raytheon's nonferrous metal separator.

De Cesare pointed out that their research is low budget. They test refuse for municipalities planning resource recovery operations. They will also treat wastes from industrial facilities. The Bureau's policy has been to develop pilot plants, then assist the private sector to develop full-scale demonstrations.

University of California. Dr. George Trezek then presented work being done at the University of California. The project was started for EPA, first doing shredding experiments only. The refuse is received from the University (mostly paper) and from a local sanitary service. Refuse is fed into the shredder with a simple front end loader. They have a plywood air classification system which they built themselves. The heavies come out underneath the air classifier and are conveyed past a magnet which pulls out the ferrous scrap. That stream then goes through a trommel and the under-size goes to an air table. A drum magnet removes small screws, nuts, etc., from the air table. By going back through once more, they get a 99 percent clean glass fraction, which has been used for building blocks. The light stream comes through the bottom of the cyclone. They have had some problems with the air lock feeder, which they have attempted to solve themselves. They also have experimented with screening. The screened material goes into a baling machine. Roofing companies have used this material.

Dr. Trezek described experiments with the minus fraction from the trommel, which normally would be landfilled. They have digested the material with sludge. In another experiment they have made pulp from the screened light fraction by using a plastic removal dilution operation. The plastic removal operation involves a traveling screen; jets of water flush the pulp through the screen, leaving the plastic on top. From the pulp they did produce paper. Also, its heating value is 7300 Btu per pound.

A new project at Dr. Trezek's laboratory is studying combustion aspects of densified fuel.

U.S. Navy. Steve Hurley of the U.S. Navy spoke about his work under the DoD program. They are planning to follow the EPA Guidelines and utilize the fuel value of solid waste. They have many options under the regional concept, in that some installations are near large municipalities they might join; others must go it alone. They are trying to bring about cooperation between the Navy Environmental Protection Program and the Energy Conservation Program.

Hurley told of plans to build a full-scale experimental unit in the Norfolk area to determine the problems, costs, etc., to make an RDF. He said rules have been changed so that an installation which practices resource recovery can retrieve the funds; this will give some incentive. The Defense Logistics Agency has responsibility for doing the marketing.

There followed some discussion of the Federal Facilities Guidelines. Robert Freeman explained that if all Federal facilities in an SMSA generate over 100 tons a day of solid waste, the largest Federal facility would become the lead agency for administering the solid waste. They may utilize an existing resource recovery facility or develop a new one. Hurley added that at Norfolk the option is being kept open for others to use the facility.

Dr. Greg Rigo commented that the Norfolk area was selected for the test because the Navy does not have an unmanaged solid waste problem there, therefore they can test and not be forced into a production mode.

Toronto, Ontario. G. C. Chisamore made a presentation on an experimental plant being built by the Ministry of Environment in Ontario, Canada. The Ministry is a regulatory agency and also a funding agency. Three years ago a commitment was made to build a solid waste plant. They are using off-the-shelf equipment. The plant can be shut down to determine efficiency or make changes. They have a 600 ton per day transfer station to handle the waste if the plant is shut down.

At the present time they are exploring both energy and material recovery. Many industries have expressed interest in RDF, and they will try to provide samples. They have an agreement with a private cement company to use the light fraction. Also the plant will be used as a training facility for operating staffs.

The plant has a small Consumat system for energy recovery. In addition there is a 50 ton per day mechanical composting module.

The plant is set up on a modular basis, and any manufacturer can test his equipment there; the information will be public knowledge. The plant is designed for public tours.

In answer to a question, Chisamore said that there will be extensive monitoring of emissions from the plant.

Chisamore was asked how his plant differed from others. He said it is basically the same. However, they hope the private sector will take streams they provide and recover the fractions of value. This would minimize the Province's financial involvement.

SESSION 5: SUMMARY AND CONCLUSIONS

David Berg, moderator, opened the session by asking, why are we here? He said that we have a fuel crisis and at the same time environmental problems. An expanded use of RDF and materials recovery could help. We are trying to telescope the birth of an industry to perhaps 10 or 20 years.

Berg noted an interplay during the discussions of near term problems and longer term optimization. A lack of data at all levels is impeding implementation in the near future and development of new unit processes and systems. We need comparative design data. We need design handbooks for the short term, orderly R&D for the longer term.

Session 1 - Systems Process Design

Berg felt that an outstanding point was that there is no state of the art. An extreme lack of information was noted, especially in four areas: materials handling; scale-up of equipment; quality and composition of raw refuse; and specifications and requirements of fuel produced. Sequencing of unit operations and modeling of alternative systems were also important topics. Trade secrecy and proprietary information were felt to be barriers to information flow.

At that point Dr. Harvey Alter said that trade secrets and proprietary information do not have to be an impediment. Comparative data, at least, could be advanced. Berg partially agreed, but said there would be reluctance to expose systems to comparative testing. Alter felt that as developers gain confidence, they will share information.

Session 2 - Selection of Equipment

Materials handling, size reduction, separation, and process control were discussed. Again, scarcity of data was noted. There was no general agreement on how much data is needed, or how to get it, in what form. Equipment has been adapted from other industries and is suboptimal. No major problems that would prevent plants from being built were identified. People recognized a need to understand basic parameters, as in George Trezek's work on shredders.

Berg briefly summarized comments in the four areas mentioned. He said there was agreement that waste handling is difficult, it is an art. Equipment choices for storage and retrieval are limited and are adapted from other fields. For size reduction, there is more experience with shredders than any other type. The state of knowledge is poor. With respect to separation, there was uncertainty about air classification. In the areas of process control, dust was of great concern. There is a need for a design manual for shredder explosion control.

Dr. Greg Rigo pointed out a need for reflective work to come up with something new.

Session 3 - Technical Obstacles

Here Berg again pointed out a duality between the need for better information on existing equipment and the need for better unit operations and systems configurations. Anything we can do to reduce technical obstacles and risks will be helpful.

Berg summarized some points made during the session. The type of data needed on performance differs according to the audience. Data may be obtained from full-scale plants or separate unit operations, and there was no clear consensus which is best. Responsibility for obtaining data may be relegated to the suppliers through performance bonds. There is a need to coordinate the gathering of data for comparability later. There was a desire for better design handbooks.

Berg then reported the results of the workshop members' vote on priority research work. The item which received the highest number of first place votes was Determine Optimal Arrangement(s) of Unit Equipment. The topic with the largest number of total high priority votes was Compare the Performance of Various Types of Shredders. Other high priority items were: Study Emissions from Processing Equipment, Evaluate Other Potentially Applicable Equipment, Determine the Effects of Pretrommeling, Develop Effective Accounting Method(s), Determine Equipment Operating and Maintenance Costs, and Determine the Effects of MSW Characteristics on Processing. The last-named also was a low priority item.

Most often named as of low priority was Determine Effect of Magnetic Separation. Others of low priority were: Determine Effects of MSW Characteristics on Processing, Evaluate MSW Segregation Prior to Processing, Evaluate Receiving Facilities, Evaluate the Effect of Drying on the Combustion Characteristics of RDF, and Determine the Effect of Drying on Bacteria and Virus.

The category with the highest priority rating was General, followed by Economics, Shredders, Air Classifiers, and Storage and Retrieval. Attracting the least interest were Receiving Facilities, Dryers, Magnetic Separators, and Conveyors.

Berg mentioned that immediate and short term needs dominated the discussion, but there was recognition of the need for basic parametric research on theory, unit operations, and systems configurations. Finally, it was suggested that we form four ad hoc committees to explore methods for evaluating unit processes.

Session 4 - Approach to R/D&D Programs

Berg made five points about this session. First, scale factors are extremely important to those using research data. There is a need to exercise all modes of R/D&D from pilot scale through full-scale demonstration.

A third point was the duality of preference on scale for gathering process data. Both large scale and small-scale operations were supported. A need was expressed to look at industrial boilers as a market for RDF.

Another point was that many options should be explored and none cut off. Possibly even some older systems should be looked at again. Finally, Berg said that there was no clear consensus on how the government should conduct its research programs.

Peter Ware brought up the subject of motivation to do research, which he said was money. He felt the large companies which have the resources and the profit motive will do most of the research. Ware felt the Federal government should fund research in areas like disease or other potential problems in the plants. As for forming committees to develop comparative methods, he agreed, but pointed out that the companies cannot be forced to comply. Ware felt there should be more workshops with specific goals.

The moderator asked for more comments on what role of the government in research should be. Floyd Hasselriis felt the government should help with government-created problems. Examples would be pollution and health issues. Berg replied that the government did not create the problems, but rather identified them and suggested remedies. He agreed it was an option for research.

Ted Sjoberg said the government should provide incentives for the resource recovery industry, municipalities, and power companies. He mentioned tax incentives specifically.

Don Walter pointed out that resource recovery is marginally economic. The government should not finance something that is going to make money. Sjoberg replied that environmental impacts may require resource recovery, but it is a speculative business. Walter suggested that the market is too small, but Sjoberg felt that rather it may be too big and speculative.

Concluding Remarks

Berg again brought up the discussion of ad hoc committees. Dr. Alter said that he had been talking with some other members of the workshop, and they felt that ASME and ASTM provide a suitable mechanism for this activity. Dr. Alter suggested using these committees which already exist. Workshop members were especially invited to participate. The group concurred with this suggestion.

Dave Spencer expressed regret that the resource recovery field was not moving ahead faster. He felt that government money was being wasted, with no cohesive effort. The companies are called upon to invest a lot of money with no guarantee of a high return. Dr. A. W. Joensen added that money for research really comes from Congress. He suggested working through members of Congress.

Bill Ryder said that the government had not helped with the Chicago plant because it was not experimental. He felt that Federal money should go for constructing known on-going processes, as well as research.

Sjoberg suggested that the government help with financing in ways like loan guarantees. He also said that the government agencies should get together and present a united front on recommendations to legislators.

Walter asked how many cities felt a loan or bond guarantee would be useful. No hands were raised. Spencer commented that grants were better than loan guarantees. He felt no policy decision had been made to move resource recovery ahead quickly and provide the resources.

Dr. Alter said that we had not considered the demand-pull financial incentives that might be used.

C. W. Fay said that it was more important to protect utilities from risk than to assure that they would make money.

Dr. Rigo said that the pressure of getting rid of solid waste as landfills are outlawed, incinerators shut down, will provide an incentive for resource recovery. Cost is immaterial if something has to be done.

Tom Lamb spoke against artificial stimulation of the industry by government. He said that the system will work when it is the right thing to do, and that time is almost here. Tax credits or loan guarantees may possibly be necessary.

Berg concluded the session by thanking those who had organized the Workshop and those who participated.

VERBATIM TRANSCRIPT

BURCKLE: David Berg of the Office of Energy and Minerals Industry, Office of Research and Development, will give us the opening remarks.

BERG: I have been working in the solid waste business for a little over three years now. Although we have meetings all around the country sponsored by various organizations, we really never get the chance to talk to the people who are most centrally involved in the research and development in the architectural and engineering community, and in the cities, and among the companies that are most involved together to talk about what their problems are and what their perspectives are. I hope that today is going to be the first of a series of meetings like this. I am very confident about resource recovery. I think that all of us at EPA recognize the need for technical gatherings in situations like this. Where we will begin I don't know. We can talk about that at the end. The Office of Solid Waste and the Office of Research and Development cooperated to put together this meeting and I would mention that because together they represent (with ERDA and other agencies) the entire Federal spectrum of activities in the relationship of solid waste. The research and development people, of course, are looking at it through the perspective of development systems and unit operations and what have you. With respect to resource recovery and the solid waste offices, we are groups inside the Federal government helping communities with their solid waste management problems. Today with this group of people we have here, we hope we have all the perspectives in the room and can bring out the issues that are related to solid waste and processing of solid waste. The last thing that we should do is try to be nice to one another, I think that the more [unintelligible] to be made the better we will all feel at the end of the day. Why is EPA doing this, besides to get everybody together in a room to fight? Besides this, we are responsible for looking at things from a Federal perspective. I think we can see that there are a lot of needs, as I said in the beginning, that aren't being satisfied, although we have several publications now in which papers are being presented. It may be that we need to have additional publications. For example, we need to get specifications together for community review. If you want to put in a system, what kind of shredder do you need or how do you decide the thing? If Union Electric is going to put some RDF in their boilers, they need to be able to work with somebody who knows specifications [unintelligible] to go into their boilers. The people in the public community systems or privately developed systems need to ask for guidance in terms of what there is developed or what's needed. I hope that we can touch on those topics and others like that and perhaps lead to some sort of example of what other facilitating mechanisms need to be put together so that the country will have a community that facilitates debate and discussions and resolutions of these various issues. The agenda is straightforward. I think you all got that in the last letter that was mailed. The first topic is system process

design. The second is selection of equipment this afternoon. Tomorrow we have technical obstacles on the agenda, and the fourth, approach to R/D&D programs. At the end we will spend about an hour summarizing what we talked about, maybe some sort of notes for the future which will appear in the proceedings that will be published at the end of this thing. Where we have found room for agreement, maybe we can put together some conclusions. Thursday we have a site visit to Resource Recovery 1. NCRR is here to host us, as well as the City of New Orleans and Waste Management. I would like to say in closing my personal thanks for everybody for being here. I hope that the discussion will be as good as the response. In very short order 39 [unintelligible] became 44 people present. Only five people invited were unable to attend, including people from England, and they had a long way to go. The last thing I would like to say is that there is one big complaint that I have about preprocessing as a topic, and that is that we don't have a good term or title. Preprocessing leaves something to be desired. It implies that it's really a secondary or primary way-stop before something else. It seems that we could come up with a term that would be a little more representative and make this topic be something less than a stepsister in its title. I'd like to announce a contest. Free drinks to the winning contributor of the new name for preprocessing--the award to be provided at the end of the meeting if we can reach an agreement at the end of the summary and conclusion session. Thank you.

BURCKLE: It seems that we have an entire technology in search for a word. We are going to put together a complete proceedings and, of course, this is going to take a lot of cooperation on the part of the workshop members. In doing this I would like to say that we are talking on the record, and we are also making an effort to provide comments off the record. If you are going to say something which you don't want to appear on the record please so state. The purpose of producing the proceedings is so that we have a record that we can use to help us formulate R/D&D programs. Also the proceedings will be distributed to all members of the workshop. It's not going to be something that is going to be tucked away and disappears in some dusty archives. That's why we want to have the opportunity to make off the record comments and remarks. Our first session will deal with the system. I have to use the word preprocessing, I don't have a better word as yet. Now as best I can tell, the word preprocessing is a contraction. At one time, I think back in the early seventies, we used the word preconversion processing, which meant the processing that came before the conversion to energy as we have used postconversion processing, which is the conversion after energy recovery, and it got contracted down. So much for my word science today. I would like to introduce Al Klee who will be our moderator for the first session. Al Klee is the chief of the Processing Branch of the Solid and Hazardous Waste Research Division of the Municipal Environmental Research Laboratory of the Office of Air, Water and Land Use of the Office of Research and Development of the USEPA. Which is why it takes us so long to get any work done because the titles are so long. Thank you.

SESSION 1: SYSTEM PROCESS DESIGN

Dr. Albert J. Klee, Moderator

KLEE: We have two major objectives today. The first one is an attempt to determine what information is needed or wanted. Given the equipment we have today, how do we select the system? What information do we need to design more efficient systems? Well, this is a matter of what information do we need to do those two things. That's the first objective. The second objective is an attempt to identify the critical aspects of design. Now in preparing for this session, John has asked several questions he thought would be at least nuclei for attempting to approach these objectives. The question is really three questions, and one of them can be broken down into two. One question involves the end product. Can we produce something useful? Can we produce something useful with what we have today (we are talking about systems now)? A second question: is there active information available for users of systems, and can one go out and select from what is available from the industrial offerings that are on the market today? A very related question has to do with those who design systems. Is there enough information now to design systems with some stated degree of reliability? What sort of guarantees can we place on design? And the fourth question, a very interesting one, involves the alternatives; can we take what is there and rearrange them; can we change the configuration; is there something coming down the pike--some new piece of equipment that might enter into consideration? These are just thought questions. If we address ourselves to these questions it might enable us to better approach the objective. The objective is primarily to determine what information we need to use what we already have. What information do we need to design more efficient systems, and what in general are the critical aspects for process design? The topic suggested, then, is specifically a summary of what I've said. What are the requirements of the product that affects the system design? What about the system liability guarantees? What about the selection and sequencing of the operations? Incidentally, we're talking both about the effect on quality and cost as well; we don't want to forget about cost. Energy efficiency is an important aspect here too. We will mention economics later when we talk about systems process design. Let's discuss our ability to do heat and material balances for design. And let's finally summarize what we know about present designs and what the present information is for selecting these systems. With that in mind, we have stated our objectives and in general have provided each and every one with some lead questions. It is up to you whether you want to address yourselves to those questions to get to the objectives. They are just an aid, i.e., some key topics. We would like to open this section to the conference members. It makes no difference who starts, but let's just proceed on an informal basis, seeking out any one of these question areas or a new question area that you feel might contribute to these objectives. Well gentlemen, do we know everything we need to know about the systems process design? I doubt that very much. Greg, why don't you start?



RIGO: We just finished a parametric tradeoff design study for the Navy. Steve Hurley is the ultimate sponsor. The study approach is interesting. We took the problem, what do you do with 20 tons of garbage a day? Then we said, let's assume we want to preprocess, and broke the processing down into nine classes of modules or functions and assigned each of these modules anywhere from three to five different approaches for accomplishing a function. Examples of modules are size reduction or dirt removal or separation of combustible and inert fractions, etc. We then went ahead and developed a very rudimentary type separation model. We took each module using the best data we could lay our hands on from many of you in this room plus several vendor's representatives and tried to simulate performance in a primary manner. Now what we did was, for example, go to an air classifier and ask, where does the paper report? Well, it goes basically in two places excluding the fugitive dust - some of it flies, some of it sinks. What are the split fractions? We did this separation modeling for each of 11 refuse components. We used the Midwest Research data. We used some data we've been collecting in the field. When all was said and done, it turned out that you can model, to some extent, what happens in systems variations. We found that today it is impossible to come up with (1) a consistent data set; (2) to account for interactions between various components; (3) it is very difficult to account for what happens to certain components when you go through a module. A prize example of this is glass. We all know when you hit glass with a hammer, some of it goes to sand, some of it goes to cullet, and some of it comes out in big pieces. Well, we cannot yet account for, in any data base we can lay our hands on, where the glass goes, and we have not been able to account for what happens to it when you get to the air classifier. The modules are strictly primary models, very rough models. What came out of this study was a very, I think, interesting finding. It turns out, as you would expect, that 20 tons a day is not too terribly cost-effective to process unless you don't have any choice, e.g., Federal facility guidelines forcing you to do it. However, if you can get some source segregation and split the metals and glass from everything else, we came up with a departure approach processing segregated streams, which appears to be, I am going to say, cost-effective in about the 50 ton plus range. Essentially what I am saying is that we just finished attempting to model systems. We have just attempted to finish a parametric study. We came out with some numbers, but accuracy of the entire system was so poor, that I'm not certain what the numbers mean.

KLEE: Greg, one aspect of modeling which has long been an interest of mine is a verificational model. How in the world can you verify? Anyone can come up with a model but the question is, is this model useful? One has to verify. How do you verify such a model?

RIGO: Essentially there are two things you can do with statistics. You can either get a huge statistical data base and try to extrapolate from it; or you can sit down and do some - in the case of garbage processing - fundamental engineering designs. You are going to develop comparatively complex design procedures on all kinds of unknowns. These procedures, after you've got them laid out, can then be simplified back into phenomenological or heuristic

models, which are the ones that are used in related industries. Then you use the available data to develop the parameters that fit these modules. If you cannot get the data to fit these models, you know your model is no good and you start over again. I think it's possible, with some of the data that's out there now, if we've got a good design procedure development program, to use the available data to validate or reject these procedures. I think that if we just simply go out and measure things and not have the collateral design development program, we are wasting money and time, and we're certainly getting a lot more data than we probably need. In fact, it may not be the right data.

KLEE: I think it is interesting to open the discussion talking about modeling processing systems because one thing about modeling is that you soon find out what information is missing. I think that I'd like to ask MRI to say a few words about their study of preprocessing as it applies to systems, just to further set the basis for discussion. Dave, I would appreciate it if you would say some words about the study, particularly as it applies to system design. This will help set a background.

BENDERSKY: We started this project for MERL Cincinnati in March 1976. The purpose of this program is to first of all determine the state of the art of preprocessing and to lead us into other phases of our project which deal with the collection of missing data. The first phase of our project, which we have recently completed, was to assess the present state of the art and to identify the research needs in this area. The results, incidentally, were recently put together in a rather thick report. We condensed some of the information in this brown folder for you to use as reference material. As far as the systems themselves are concerned, first of all we are concerning ourselves with waste-to-energy systems and those waste-to-energy systems which process the waste in some manner before its conversion into an energy product. We are not talking about waterwall furnaces, etc., which do not process the waste before use. The first thing we did was make a survey of those kinds of systems that exist now and those that are planned. What we found is that approximately 50 systems--that is waste energy systems with preprocessing--are either now existing or in the planning stages. That's the base that we have to work with. Of these 54 systems, approximately 12 to 14 are scheduled for operation this year, in other words by January 1978. As you are all aware the dates are the best that we've gotten from the people who are responsible for these systems. There are three groups of people in this industry that we're trying to satisfy. First of all we are concerned with the system designers--the people who are designing these systems. Secondly, we are concerned with the manufacturers of equipment; and finally we are concerned with the user/operators of this industry. We have interviewed representative groups from these three basic sources. As for an overall picture of what we have done so far as to the state of the art and needs for research, we find that all three of these groups need additional data beyond that they now have. The system designer needs more information on equipment alternatives and arrangement alternatives, not so much from the manufacturer of the equipment but how it will actually work in the field on MSW (municipal solid waste). As we all know this is a young industry. There is as yet comparatively little data based upon actual

performance in the field under full-scale conditions, so the industry in general is operating with lack of data simply because the industry just hasn't progressed that far yet. More field test data is required under full operating conditions. This is a generalization. Specifically, there are problems here that evolve into what we call cost effectiveness. In other words, you need more than just how well will a piece of equipment perform, plus under what price tag. As we all know there are tradeoffs in this as well as other industries. The old saying is you get what you pay for. Unfortunately right now there isn't enough data for comparative analysis if you want to put together a system and do a detailed cost analysis and feel real confident that you are designing an optimum cost-effective system. These are some of the problems that the systems designers face. There isn't enough data. Now they are using all that they have available, but unfortunately there isn't enough yet. We are finding that the manufacturers of the equipment are handicapped. They are trying to provide equipment to the systems designers and the systems users, but they are handicapped because they aren't sure first of all under what conditions their equipment has to operate in the plant. Secondly, there isn't as yet enough intercourse between the manufacturers and the users and systems designers. There are a lot of personal contacts going on, but as an industry it hasn't yet started to mix enough so that there is open literature--open data--that everybody can use. Everybody is exchanging this kind of information on a personal level now. There has to be more of this kind of information gathered for the whole industry. Manufacturers are interested in how their equipment is working in the field; they don't always get this information. I have asked a number of them "how is your particular piece of equipment at such and such a plant working?" Well, some manufacturers make more of an effort to get this information than others. Some of them say we really don't know because things change from day to day out there. There is still not a good exchange of information. The manufacturers are handicapped basically two ways. One, they are not sure what their equipment is supposed to do under what precise conditions. They don't know how their equipment relates to an allied piece of equipment--a shredder versus something else down the line, or other piece of equipment with regard to another. The interrelationship or the arrangement of equipment and the effects of arrangements are not available yet. So these are some of the problems that the manufacturers are dealing with. The users, we find, or the operators of these systems, are handicapped because they don't really know when they are given the keys to the plant how to operate that plant under optimum conditions. There's a lot of worrying going on and has to go on when any new plant comes into being. What it means is that a lot of self-education is going on. The operators of the plant have to learn themselves how to operate the individual pieces of equipment and the total system efficiently. They wish they had more instruction books or knowledge so that they wouldn't have to go through this extensive, costly learning program. Many of them have to change things as they go along in order to make their systems more optimum than it was originally designed. These are some of the problems we have found by looking into this field as far as systems design and operation is concerned. I will go into more detail later, but Al, that is a sort of summary of what we found as far as the system is concerned.

KLEE: Thanks, Dave. We found that coordination was needed on equipment alternatives, and coordination of equipment manufacturers with system designers. People operating these plants certainly need more information, not only on the equipment but on the system as a whole for more optimal conditions.

ALTER: Let me suggest a little reorganization of what Dave has said. There now exists the literature in other fields, particularly minerals processing. Given a piece of equipment to operate over a range of particle sizes, with a variety of feedstocks, to perform in a certain way, you can interpolate and come up with some projected performance. Appropriate assembled data do not exist. I suggest that this organization meeting will lead to providing data, but on what pieces of equipment? Dave organized the materials handling into size reduction and into separation. It's interesting to me the materials handling seems to have been ignored. When the operator goes into the plant, and strives for optimum performance is when he gets hung up on the materials handling problems. He never gets around to research aspects, or if he does, he's too busy trying to make things operate that the measurements aren't made or aren't reported. Information is transferred by conversation not by the written word. I'm appalled at the lack of information--a "no state of the art" if you will, or "poor state of the art"--of materials handling in refuse processing, the dust and the blowing and the dribble, and the consequent housekeeping problems and fire hazard. I'm appalled by the fact that it seems that many plants do not know how to mate a conveyor to a shredder, or a conveyor to a bin. I raise this to the group because I've seen overseas beautiful, clean plants, no blowing, no dribble, no dust, clean floors without large crews with brooms. Those of us who have been in plants throughout the country see quite the converse. I think that before we can learn something about size reduction and separation on the operating mode, we will first have to learn how to handle the material so as to avoid startup problems, to avoid housekeeping problems, and avoid having to account for the portion of the materials balance flying all over the room. I suggest that we try to hold the discussion to maybe these three categories--or others which people may want to suggest.

KLEE: Thank you, Harvey. You're identifying one of the critical aspects of the system design--materials handling. To my mind, we can separate size reduction and separation into three categories--mechanical, pneumatic, and an "other" category.

BENDERSKY: We in our work organized the equipment into two basic categories. First of all there is what we call unit operations, which are those pieces of equipment which actually change the character of the waste stream. I'm talking about shredders, air classifiers, magnetic separators, etc. Those we call unit equipment or unit operation. Then the second classification that we have is supplementary equipment, which includes the conveyors, the storage, things that do not affect the character of the waste but are very important from a standpoint of handling the waste stream. Incidentally, on page 10 of this handout we have a list of the basic pieces of equipment we have been looking into and they are identified by these classifications.

There's a dozen areas we looked into--all the way from receiving facilities down to fire control systems, and they roughly spread into about six unit operations and about six supplementary, which are all-important to the operation of the entire system. There's been a tendency to ignore the handling equipment and some of the very important aspects. It doesn't do you any good to have a shredder unless you can get the material to it.

LEVY: I would like to get back to Harvey's comments with a couple of my own comments and maybe we can follow throughout the whole two-day session, and that is to get back to what Harvey suggested. I would like to raise the question how could we find out this information. Maybe we could have a discussion on what kinds of steps we should take to answer these questions and evaluate the existing systems, or paper studies or comparisons of other industries or laboratory comparisons. What specific steps could we take? I think we get into that and elaborate at this point and get into some specific tasks that we can actually sink our teeth into.

BURCKLE: I'd really like to reserve that sort of discussion and type of approaches to developing the information and satisfying the informational needs.

KLEE: Does everyone agree with Harvey that materials handling is the critical area?

CHANTLAND: I would have to agree with Harvey that materials handling probably is one of the major items in any processing system that has to be given great attention and probably is one, certainly from the aspects of investigation so far, that is extremely critical. It's critical from manpower, it's very critical simply from running an operation. I think, however, when we started out here I have to back up to what has been said, what is the end product. I would have to say that question probably is the most important and must be answered if you are going to talk about the selection of systems. That's the one where the economics is; that's the one that determines basically what kind of equipment and so forth you are going to put into a facility; that's going to determine whether you are going to have some pre-separation that we talked about here before. It goes clear back from one end clear to the other. If you don't satisfy what the end product is going to be, as an example, you may be able to put up with some glass or some rubber in some cases, maybe you can even put up with wood particles - large or small. In other processing you can't put up with this type of material, so there is an importance there in terms of equipment selection and the selection of the system from that point on back.

LINGLE: Let me follow up on Arnold's comments and pose the following question relative to producing a marketable product. The question is, how much processing do we have to do to produce a marketable RDF? The early attempts at producing RDF, and I guess the attempts that are still going on now, is basically one- or two-stage shredding, plus probably single-stage air classification. When we look at the composition of the RDF, we can look at its performance in a boiler, we see that we don't have a very sophisticated

material and that may be one of the reasons that we find the utilities very reluctant to purchase that material. For example, one of the things we find is fairly high moisture content in RDF, and that moisture content causes increased gas flow to the ESP, and that in turn results in increased emissions. That was one of the conclusions and results of the testing in St. Louis. We also find that there is a significant increase in bottom ash when you burn RDF in the boiler. That's partly because the RDF has a high ash content, higher than coal, and partly because the particles simply don't all burn. Now, if we want utilities to burn this material, we may have to do something to improve the product. How can we do that? Dry RDF to eliminate some of the moisture; use additional screening or classification or other processes to reduce the ash content somewhat. In short, we're going to have to move to processing systems that will produce a higher quality RDF.

WILES: I would like to ask a question on the other side of that point of view, Steve. Perhaps the utility industry could use a lesser quality RDF rather than what you are talking about with some somewhat minor modifications of the system. Maybe that's a more cost effective way to go. I would like to have some input from participants in that area.

RIGO: I think the question cannot be how high a quality of fuel do we have to produce to sell. I think it's got to be how poor a fuel can we get away with making and use it successfully. Because every time you process, your cost goes up, your reliability goes down, just backing up what Carlton said. So those of you who are playing around with low quality fuels, maybe we can look at it from that point of view, how low quality can we go? We're burning pellets at Hagerstown right now and we are getting deteriorated fuel on occasion--not very bad, it's about 16-17 percent ash. I have seen pellets produced with 12 percent ash. The fraction fines range from 15 to 50 percent. The pellets still go in, and guess what, we can run a boiler on them. We have burned 100 percent pellets, and experienced some derating, but no major problems. We burn less, we get no derating. We don't have a lot of time burning d-RDF yet, nowhere near what Ames has. But to date, we're fairly encouraged, we are working with Harvey Alter now and getting ready to start with him trying to answer the question--how low quality a fuel can we get away with?

HOLLANDER: Mr. Lingle mentioned the report from Washington; he put it in the context of the utilities. North Dakota lignite, Wyoming lignite, the subbituminous coal, all have more moisture than most RDF generated anywhere. And yet, there is this urge to embrace these lower Btu, high moisture, higher ash coals, merely because of their lower sulfur content. Actually, when we look at a fuel product there are two basic aspects instinctively considered. What is it you would like to have and what is it that you really need? When we look at coal burning, does anyone really know what is being burned at any point in time? What are the variations in coal quality that you must be able to cope with? There were periods recently at a station that gray coal was being consumed or just because it appeared black it is burned as a fuel. The system design and operation must have the capability of contending with variations in coal moisture, ash content, including

extraneous material as well as calorific value. Very little of the coal used for steaming is beneficiated. Why refine the material--why massage the material any more than you absolutely have to--for a particular use? However, we must recognize we have various degrees of sensitivity to the quality of the fuel material for the application and genuine need is very site-specific. But in our passion to come up with the ultimate in product quality, perhaps we are overreaching, which may not be universally necessary. We should consider what Mr. Chantland implied--let's take a look at what we can get away with or what we can tolerate, and not impose upon ourselves the over burden of seeking the penultimate. Perhaps in that way we can have higher availability and a more consistent reproducible product, which probably also is most cost effective. Now we can't write a book of operating instructions for any new plant, either in the power industry, or industrial utility. Many times it takes six months or a year to get a unit operational and on-stream; and we are addressing an area of process activity where supposedly we have all the answers. To fully expect that this is going to happen in any waste processing plant--walking in and pressing a button, or reading some sort of conceptual operating book, we are just deceiving ourselves. We have to go through the effort of trying to get an operational plant that is satisfactory for the particular purpose at this particular location. In time you will develop specific normal and extraordinary operating and maintenance procedures. Unfortunately, if you go back to one of these plants considered operational--go back six months or a year later--in too many cases you have to try to find the same operating people you talked to six months ago or a year ago. It is this on-going process of reeducating and indoctrinating the new people coming on-board that is also a real serious problem. There are very few plants where there is a deliberate, concerted program for making certain that a new man who comes on-board is aware of all the trials and tribulations experienced and the procedures to be followed to operate the system in the manner which satisfies the current objectives.

FAY: I think, depending on which side of the coin you look, how bad can you make it or how good can you make it--I think that at this stage in our development we should not be pushing too hard on how bad we can make it. I think what we don't need today is a couple of failures, or maybe I should say a couple more failures. If the Milwaukee project should turn out to be a lemon and the Commonwealth Edison project turn out to be a lemon, there's going to be a terrible time trying to get utilities involved. I think most people agree that the utility with large boilers is the logical consumer of the fuel, and I think from the utility aspect there are zero incentives to get into this business with exceptions. If the utility is municipality owned, then they've got a mission I guess. But in our case--in most investor owned utilities--it is not our problem. To get into it, we are taking on problems and we're taking on risks and they could be serious risks. We don't really know how bad those risks are today. We get enticed into this business for various reasons, I guess, and what we really need to do is have some real success stories. In determining what kind of fuel you should be making, I think you will have to take a real close look at where you are going to put it. If you are going to put it on a grate stoker someplace, I think you can do a lot different than if you are going to try to burn this in a small utility boiler, and a small utility boiler,

I suspect, is going to be a lot different than a large utility boiler. I think you are talking today about a customized kind of system that you've got to be looking at, and I'm a little doubtful that you're going to get all this nice data that we talked about a few minutes ago readily available. Assuming that some of these turnkey operations that are going on are successful in that they do turn out a product that is consumable, there are probably some tricks of the trade, some little gimmicks they use along the way that for competitive reasons they may not want to flush out for the public eye and their competitors. So I don't think you should hope too much that you're going to get all of the data from every project to make the next one you build real easy. I think it's going to be a tough competitive struggle.

KLEE: Between the last two speakers we have the classical difference between the buyer and the seller, or the producer and consumer, laid out on the table.

BERG: I was just wondering--maybe what you need is a success, but what is it you really need? A success tells you that you can do it. What would make you more comfortable?

FAY: I think that from the utility aspect, success means that we are able to use this fuel; that it's not destroying our boilers, it's not causing pollution problems such that we have to backfit a plant at great expense or shut down because we can't meet air regulations or water regulations. If burning this material should reduce the reliability of our major boilers--which in our case we are using the largest ones on our system--if we take those off the line because of this process very often, not only Wisconsin Electric but the Public Service Commission of Wisconsin and probably the people of Wisconsin are going to be not very happy because somebody obviously pays for that in the long run. So we need to have a thing that hopefully would operate like we hardly even know we are burning a different fuel--and maybe even a better fuel. If I can point five years from now and say the slagging on the boilers is a lot less than it used to be, there's an inducement.

HASSELRIIS: There was one philosophy many years ago which was the only way to burn refuse is on a grate, and that's with no processing. We've come down the road a long distance since that time and that type of processing is almost forgotten today. The question would be--what's the other end of the scale, and if it may be appropriate to make major jumps ahead. We are doing this basically by jumping entirely across the whole span to a fuel which is a dry powder of extremely uniform characteristics, which would meet this request of a utility for a fuel is actually much more uniform than the coal, which they are well equipped to handle. It remains to be proven exactly if the economics of the processing goes that far, because there are more steps in it. On the other hand, the moment that you make one major jump, which is to go into the drying phase, you're immediately in a different type of fuel of very uniform characteristics. There is initial processing and the result is a fuel of a very uniform characteristic derived

from an input of extremely nonuniform characteristics. One of the major things I wanted to contribute at this point in terms of preprocessing is that number one, if you want to make a general rule, the manufacturer can deliver about half of what you promised us based on the current technology. If he says that the mill is good for 50 tons, it is probably good for 25. That is probably fair. If he says the conveyor is good for 50 tons, it is probably good for 25. Basically this has gone right down the line because our methods of obtaining bids and getting back information are idealized to a point to disregard the variations of flow that take place for many reasons--the variations and constituents. So what happens is the manufacturer says, well the mill, that's average what I told you, but it won't take the peaks. The peak becomes the average for the processor. If the motor will trip out at 50 tons, then that is the peak, but the average relating to 50 tons is 25. So day in and day out you get 25 out, but you bought a 50 ton machine. So that's something that I'm sure all the people who built these plants have come to learn. I think it's time for us to address that fact. The variations we have to live with within a diverse fuel are extreme in comparison with other types of material. Some studies I have seen or made myself, trying to find out what the variation of any particular material might be. If you say plus or minus 25 percent in the characteristic and nature of a material of any kind or any piece of equipment, that's probably a fair number. It's all of that. In other words, whatever you designed it for, it can be less or more 25 percent of that characteristic. That would be in bulk or weight, in density, in glass composition or any other characteristic you want to apply. Therefore what we are really designing to is not a point like in a simple system that carries water, something that you know the properties of. It is a wide band, it's a very thick wide band with a plus or minus 25 percent, sometimes plus or minus 100 percent, 200 percent in the case of cans or glass or small constituents of the system. You may have a huge variation in one constituent, and we have to understand that all of our equipment has to absorb, like a great big balloon, the residuals that result from their usual variations. How anybody is going to know what the variation is going to be in a plant is, of course, our big question. We know that industrial waste is totally different from residential and you have to consider in what size units the variations come in. Yet one complete truck load of roofing shingles, and that does not average in any way. It's that type of a variation in taking your bulk refuse which has to be considered. Yet in the end by sufficient steps of classification, you can end up with something that is almost pure cellulose and a good clean fuel product. The question is the value of that product and how much machinery you are willing to spend to produce it reliably.

WISELY: I thought that it might be of some interest to the people here to learn a little bit about the philosophy that prevailed during the very initial St. Louis work. Both Steve Levy and Bob Holloway, I'm sure, were involved to some degree in certain of the discussions that took place relative to the quality of the material and the degree to which it had to be processed for burning in the Union Electric boilers. The first reaction that we got from UE was purely and simply this (and this is in complete substantiation to what Herb Hollander said) that the variability of the

coal which fired through their facilities was such that it really made little difference as to what quality we were actually able to inject into the boilers. In the first discussions we had, the general reaction was, why even remove magnetic metal? We concluded that this was such a simple procedure that it was ridiculous not to do so. You may remember that the initial facilities did not even include an air classifier, and this was purely and simply because we didn't even know whether the stuff was going to burn when we blew it into the furnace. We thought it was going to, but we weren't completely sure. The next step, of course, more of a necessity than of a desire to clean up the fuel, was to install the air classifier which was installed purely and simply as a means of making the operation more reliable. The only reason that that had to take place was that the pneumatic feeders would not operate when they got chunks of material that wouldn't readily burn, and it wouldn't actually go through the feeder. In contrast to that, in various subsequent investigations, it has been quite apparent that there are facilities that could take no material of very much a lesser quality than that that Mr. Hasselriis has discussed. In certain cases it may be very well that is the only type of material that might be utilized as some sort of a supplemental fuel. There have been cases also that we've run across, one very current one, in which the boilers have a very limited bottom ash handling capability. In this case, in order to make the material function as a fuel within the boiler, it is going to be necessary to remove as much of the ash--probably more glass than anything else--as we possibly can from the material. In short, as Mr. Fay has said, it's going to be necessary to consider in every single facility that is really given attention, the individual circumstances surrounding that individual application. In many of the larger boilers, sure, you can fire 3/4 inch stuff with some reasonable ash content without the moisture content getting so blasted high that you can't handle it. This gets back in the materials handling problem, of course, and from that point on it's purely and simply a matter of getting an agreeable, rational sort of a compromise, really, as to what quality material you can actually burn. For the most part the utilities, I think, have been very realistic and really not too demanding as to the quality of material that they are willing to take. Obviously they want the best they can get. They also recognize, of course, that it is not always possible to get the quality they would like.

KLEE: We've made a number of points this morning; two seem to stand out. Of course, the big one was the matter of looking at the final product. In this particular case looking at the fuel and realizing that you just can't design a system unless you have some end product in mind. The other, and I think we discussed that to an extent, that some of these other issues ought to be looked at also. Harvey brought up the matter of materials handling. Everyone seemed to agree that this was a problem. [Unintelligible]. Afterwards air classification was added. Back in those days you pretty much could sequence. You knew what a preprocessing sequence was like. I doubt if you can do that anymore because there have been other things added; there has been two-stage shredding now. The use of trommels now, for example, has come into the fore to a point where some systems--the systems

over in Italy, for example, that hardly uses any shredding at all--they rely to a great extent on trommeling. Now I've looked at all of these various reports generated about processing systems and they differ. People make different selections about which item comes first. Here's a good question: what have we learned about sequencing? We get in there and we grind first, or do we do some trommeling first, do we try some sort of separation first? What have we learned about this? What don't we know about this particular area? If you have some contribution to make in either the area of materials handling alone or the sequencing operations, I think it would be valuable at least to say something on that, albeit if we think that the fuel question is more important we could go back to that. I would not like to see some of these other important areas overlooked either. Harvey?

ALTER: Let me address almost all of your points. I like your point about the sequencing because it is the first time it focuses on the need for customers' specifications for the fuel or whatever else the product is. I would like to suggest that the recent plants--many of the recent RDF plants (to dwell as Steve did) copy from other people. I do not denigrate the designers for doing this. The municipal customer and the bond counsels like it if it's like everybody else's. They want to go into the showroom and kick the tires, say paint mine green, and we wind up pretty much replicating the historical development in St. Louis. I noticed our conversation this morning was following a similar line. We started talking about plants as they now exist and mostly exist--the shredding and the air classification sequence, etc. We ought to go back, though, to customer specifications and objectives, processing objectives, and then talk about sequence of operations. Example: It is certainly an objective in making refuse-derived fuel to reduce the ash. We have one base line level of ash as a result of the early work in St. Louis, and now Ames, and soon elsewhere. It's historical and a lot of people said it's too high. Let's examine the refuse. I think there are three different types of ash in the refuse. There are the large items, the stones, the cans, that won't burn. They have to be removed. There's the second type of ash, which is if the material is shredded and some of the non-combustibles are crushed and thus coat the combustibles, a second kind of ash. By the way, in either category I will include hunks of rubber, leather, or heavy plastic which don't burn, not in the sense they wouldn't burn in a laboratory, but their rate of burn is too low in an operating boiler. In the third category of ash is the ash inherent in the materials we are dealing with. The tree grows and develops some ash, and there's no way we can get that out. So we say if the objective is to reduce the ash, now let's use that objective to determine the sequence of events--the sequence of processing to take out those first two categories. Return to your comment about trommels. The trommel, it appears, will take out some non-combustibles, the glass and the rocks, before they ever get crushed to become the second category of ash. I use that as an example of the objectives driving the sequence. I'd like to see some of our conversation this morning repeated, but from the point of view of objectives to produce a specification fuel and thus drive design of appropriate sequences of operation--not existing sequences.

WARE: I would like to address the whole system design problem from our point of view. We already had a process. It had been developed for coal

liquefaction and gasification, and we decided to modify it or utilize it for the processing of municipal solid waste. In this way, we already had a set of end specifications that we had to meet. The pyrolysis system that we have is quite sensitive to particle size, to ash content, to aluminum and glass content, and we had to design a front end that would satisfy an existing unit. When we started to get into the design of the front end, obviously we started with classification and characterization of the streams and how we ought to handle these, to end up with a feedstock for our pyrolysis system. The further we got into the design computer model, the more we realized we knew nothing about it, and that any amount of characterizing wasn't going to give us a system. And this reflects the comments made earlier in this session, that first of all the data is very hard to generate, and secondly when you get it, it's not worth that much. So to be quite honest we came up with a position where we couldn't design a front end process. So our first approach was to beg, borrow and steal. We prowled around the country and visited every other facility, not with the object of copying them; more to find out what they had done wrong. And we certainly learned plenty of that. By talking to the people right down on the plant floor, the maintenance superintendents in most cases, we learned a few of the things they had done right. Then we came back and sat down and saw how we could shuffle it together, again reflecting the comments just made, that we had to characterize it in some way by having a sequence, by getting out the materials that we didn't need first, prior to shredding, removing materials after shredding, again which we didn't need. Our objective was still to make feedstock for pyrolysis. It wasn't to make any of the other secondary streams. Then we settled on the design, as you ultimately have to do, and decided to make it work. In this way we are admitting that what we came up with is probably not the best way to go, we wouldn't claim it was, but we designed in enough flexibility that it would work and that we would be able to generate data from it. What we are saying is that we virtually built a pilot plant. It's a commercial pilot plant, whose objective is to find better ways of doing what we probably have done wrong already. Now in the chemical industry, the normal way of going to a capital plant is through years of research and pilot plant work. You really have to generate a hell of a package before the board of directors will approve expenditure. It seems to me in the solid waste business this has been vastly accelerated. We've jumped in with both feet in a lot of cases and built a plant first and tried to make it work. We have done the same thing, to be quite honest, and the only thing that we would claim is that in our design we have left enough flexibility in it that we can operate within a very wide range of variables, and that we can generate the data. Our plant is highly instrumented for the sole purpose of generating data, so we can do it better the next time. Coming back to the question of system process design, this whole business has been so accelerated in the past three years and the pressures of the environment, the people, and the government, have been such that some of the elementary steps of process design have been completely overlooked or bypassed. Now we are at a stage where we are approaching commercialization in a lot of areas, and we have the opportunity to collect the data. Now here's the thing that I fear most of all--in the generation of these plant designs of all of our various

systems, we've learned a lot of things that we're not prepared to part with. That's the way we feel, and that's what I find when I visit other plants. It takes a lot of socializing and a lot of exchange of information, on a personal basis, before people are ready to divulge what they have learned. Very little of it gets back to the manufacturer, and understandably, because there is some resentment on the part of the customer. He didn't get the information he wanted in the first place from the vendor. I wonder whether today we are going to be honest enough or friendly enough or free enough to part with the information we have learned. That will for me be the major benefit of this session we are having.

POWERS: I know Peter quite well, he was out to my plant. I second most of the things he says. In Recovery 1 and Waste Management, Inc., our parent firm, we designed, speced, and built the front end of Recovery 1. Waste Management and the National Center are co-designers of the back end of Recovery 1, which is the recovery portion of the project. In going through just the primary parts of the operation--the specifications of the conveyors, specifications of motors, specifications of the shredders--trying to evaluate this equipment from the vendor's data, their handbooks, their brochures, it's a virtually impossible task. What you finally wind up with is a situation where the buyer beware. Guarantees, warranties--in refuse you can forget it. They aren't there. One of the gentlemen over here said if you buy a 50 ton shredder you can expect 25 tons. We have been a little lucky, we bought a 60 ton shredder and we get 75. As part of our doing, not necessarily the manufacturer's. It's an operational situation which Peter can attest to; you find different things that go wrong and you fix them. There's nothing in the book that tells you how to fix them. It's a situation of day-to-day living and how to make the plant operate. Flexibility of design is very important. I don't know where we can go from this point as far as RDF. In New Orleans we do have a big problem because we don't have any grates to burn anything on, everything is coal and gas, so as far as that particular phase of the operation in this area it's almost nil. We would have to look to new small businesses to burn in this area. I don't know where they are going to come from--we need more help from the city, I guess. That's my comments and reinforcing Peter's stand.

KLEE: On this business of equipment sequencing, George has been working with secondary shredding. George, am I misstating some of your conclusions when I say that you found that the energy requirements to grind to a particular average size or size distribution is about the same whether you use one shredder or make it in two passes with two shredders?

TREZEK: I have some slides of that I am going to show this afternoon in which we laid out different sequences of equipment and how much energy it takes to make the final product.

KLEE: We'll talk about this in the equipment session. Still, from an overall process design standpoint, things like this are important. I bring this up because this is something specific, and Peter had said that a lot of information isn't getting around; it's being held back for proprietary

reasons, lack of communication or mistrust in some cases, and it is difficult to really come up with some concrete statements. Should you trommel first before you grind? A couple of years ago everyone said sure, grind it first before you did anything else. They were "positive" about that then, but where are our positive statements now about these other alternatives that have come down the pike? We can't seem to get a consensus from the group.

LAMB: I don't think we can get a consensus and there isn't a right answer. Maybe you want to shred before you trommel; if you do why? Maybe you want to do the other way around and, I don't think we should be looking at specific answers because there aren't any. It really depends upon how the system is going to be applied and even one manufacturer may want to apply his system differently, for example, in one case he may want primary trommel after shredding. The thing that would be helpful is to know in making these choices, what impact does that have on what you are trying to accomplish. That's where you need the data. I see the real dilemma as coming and depending upon who generates that data, what is the availability going to be. What is the incentive of the private sector to share data among themselves or with the public sector, particularly if it's selling plants competitively or offering services competitively. A company goes and spends a lot of money in developing this information, frankly guards it kind of jealously. Will only tell what he thinks everybody knows anyway, and really is not going to tell the answers that he really thinks are the gut issues. I sit here and listen to people talk about trommeling and say, oh boy, we get so many pounds per square foot, or square foot per hour. I listen to them and they run a test for 15 or 20 minutes or maybe as long as 8 hours. You want to trommel for a month and see if you get the same data. Everybody says they can solve the problem of blinding. Who has done it? The only time you go and see a trommel is after somebody cleaned it and they put on a demonstration. We do the same thing. But are we setting our objectives too high, maybe we should so when we fall short we've accomplished something good. But the real meaty questions which are being asked here--I frankly think most people who have much insight into the problem may not be willing to share it.

KLEE: Are you pessimistic about this? Do you think this information is going to take years, if ever, to become disseminated?

LAMB: I think that the information that the designers would really like to have, the complete package to be certain when they build a plant, that it has some opportunity to meet the reliability criteria whatever they be. I think expecting to find that information from handbooks or publications or to be generously shared by others in the business is very optimistic. That doesn't mean that we shouldn't have meetings like this and do everything we can to encourage discussion and interchange, but I am concerned particularly in the areas where people think they have an edge, that there's going to be little incentive and their managements would be concerned if we the technologists went out and completely shared with everybody everything we know. It's been in most cases one of very very large costs.

TREZEK: We've had a lot of people come to our lab, a similar kind of thing, I find sort of a one-way conversation. They come in and want to see what we're doing; we get out our publications and we start telling them, but we don't get this kind of thing back. I can see it's a proprietary thing. We found one interesting area in the shredding work that we did. When we got into it I felt the equipment manufacturers were just really enthusiastic about finding out how their machine works with refuse, but I found it quite the contrary. It seems as though people really didn't want to know that much about it.

KLEE: Herb, did you have a comment?

HOLLANDER: Yes, I did. Whenever I get a little discouraged I sort of step back out of the picture and look at it, and ask myself--look how far we've come! Five years ago would you have had a meeting like this? Five years ago how many people in this room were even aware that this concept was at all viable? I am very encouraged! When I look at what happened to just one piece of equipment, the shredder itself--the evolution in design, the number of people that have become involved and have addressed the problem. Five years ago no one ever heard of a trommel, although a trommel's form has been around for many, many years. The idea of burning waste reduced to a controlled size was startling when St. Louis was first emerging. Frankly, it's a conditioning process. You have to massage these things, you have to talk about them, you exchange experiences, especially the catastrophic ones, or what was catastrophic to you was par for the course for me, or things of that nature. So I am very encouraged, and I see down the road this entire concept maturing. We will better define our needs, we will try to avoid complexity, we'll try not striving for getting to the moon in one year or two years. The philosophy that was related to us by Occidental Petroleum is a good one. They recognize they are not going to attain their goals immediately and that it is a growing process. I think meetings like this are essential. They are necessary. Hopefully there will be expressions from everyone who attends the meetings and not merely absorbers. You have to have this interchange of views, recognizing we all have our own vantage points and are maybe naive in some areas but knowledgeable in others. So I am encouraged, Dr. Klee, I think that we have made great progress in the last 10 years. especially in a democratic process.

DE CESARE: This follows what Herb was saying. Six years ago when the Bureau of Mines first put in their trommel and shredder, we found out that you've got a lot of other variables which everyone who puts in a full-scale plant or a pilot plant has to realize. No matter of the scale of the plant he's going to have a pilot plant no matter how big it is. The first one is going to be a pilot plant. When you make differences in designs, make changes, whether you're doing it the way they are doing here in New Orleans, or the way you are doing it in Americology, it's going to change the system enough that you've got to put in the flexibility and take care of the differences that happen. For one example, take a hammermill. First thing that happens when you put material through a hammermill, it blows out the bottom, so you need an exhaust system. Well, you go to other hammermill in-

stallations and you'll see it go straight down without exhaust system. What determines what's going to happen? You change the refuse, change the moisture content, it's going to affect your air classification drastically. Every single condition all along the way--there's no definites anywhere. When you make changes, unless you build identical plants and put the refuse through, you are not going to come up with any concrete decisions. They are going to have to need flexibility and have variations all along the line. So any plant they're talking about--like Occidental--they shouldn't feel alone that they are building a gigantic pilot plant. Teledyne has a gigantic pilot plant in Baltimore and anyone who builds it is going to have the same thing.

KLEE: I'm going to be a dissident here. This seems like a cop-out, saying, well you have too many variables, therefore you can never make a statement. You've got to use Occam's Razor or the Law of Parsimony to bring some order out of chaos. It seems to me that at least one can generalize some basic fundamental cases--three, four--and make some statement about this business of sequencing or equipment selection, instead of just saying well, there's just too many variables and we give up. If we use that for a criterion, we'd never build an airplane, for example.

DE CESARE: That's OK for a pilot plant, but when you try to scale up, you get entirely different problems. When we first built the plant there were no air classifiers, so we built our own. How do you scale up an air classifier; how do you scale up all of the equipment? They're all designed empirically.

KLEE: That's another good question too.

DE CESARE: When you have empirical design, there's no data base. Your materials change so drastically that there is no good way of scaling up. So what good is it to optimize the pilot plant when it doesn't do you any good because you are going to have entirely different problems when you scale up.

KLEE: Good point. I'm glad you brought up scale-up; that's going to be something else on the list.

RYDER: I would like to comment on some of the statements that have been made here. The thing that I keep hearing here is about these manufacturers who just can't seem to get data to improve their product. They get their equipment installed and you would believe that they pound doors down trying to get data as to how well their equipment is working. Nobody will give it to them. I've never seen that. I've seen a lot of pounding on my door to bring potential customers in and to sell them more of the thing that they sold me. But in general except for the "research" that they went into in trying to get their equipment to work for acceptance purposes, no real effort seems to have been made to get any further data. I certainly wouldn't hold anything back. Secondly, as far as an interchange of information is concerned, we should understand that these people are in a very competitive

market. They've got a product to sell and why give out information which may benefit their competitors. So where are you going to get this information? You are going to get it from people like those in this room-- people like this; engineers, and professional people who are just going to have to see what's around, make some judgments and move from that point. Now even within this group, you'll have certain competition, i.e., consultants who are vying for jobs in various cities. What consultant wants to run a gratis training program for other consultants who are his competitors. To get back to the comments about the scale-ups, it would be ideal if we could take ideas such that the Bureau of Mines pioneered and scale-up the ideas into an on-going plant. However, in the real world, I cannot afford the time for a full-scale experiment or R&D project if you will, as I've got to get rid of the daily production of garbage, otherwise our City is in trouble. In my opinion, moving from the lab to a full-scale plant is another experiment, only this time it is full-scale. What am I going to do with all this refuse if the equipment becomes an R&D project with its consequent large amounts of downtime? If the Federal government wants to pay for full-scale pilot plants, I'm all in favor of it, but they also should pay when the pilot plants get bogged down and the refuse piles up. So far, the only Federal money I've seen is a small dribble to conduct evaluation tests. We're not being hard-nosed about it, but we do have an on-going refuse problem-- about 5,000 tons a day and it won't go away.

TREZEK: The scale-up problem which we looked at when we started our size reduction studies--it occurred to me that we have to have a place to start that was of a size that was somewhat realistic. We couldn't believe that if we had sort of synthetic refuse, anybody would believe what it was that we were going to do. Yet you have to start at a place which is pretty big, I guess is what I'm saying.

KLEE: Sometimes you need more than two points to design scale-up. Suppose, for example, you are designing a boomerang and just have two points; you can't extrapolate on a straight line!

RIGO: On the subject of analyzing plants, I agree with you that it is going to cost money to analyze, for example, your plant up in Chicago. I do not believe, however, that this analysis cost interrupts your processing. A properly designed experimental analysis package has got to recognize that the plant must operate in an uncontrolled manner, as it normally operates. It must not interfere. I believe personally that this is quite possible. If you design an experimental program which requires interruption, you are going to be biasing your data so badly you might as well not have bothered in the first place. When we analyzed Franklin [Ohio], we did not interfere with operations. What we are trying to do with Baltimore (if that plant will ever run) is also not interfere with operations. I don't think that is necessarily a real concern. It calls for coordination, it calls for cooperation, I agree it calls for external funding of the analysis, but you should have no fear of it interfering with your day-to-day operations. If it does, you don't want to cooperate, and you shouldn't cooperate.

BENDERSKY: I just want to say that our program is going to go into full-scale field testing, and we are very much aware of the need to avoid disrupting normal production operations. Generally speaking, what we have found in our analysis so far of this problem in testing in full-scale plants is that certain information that you want is available and can be obtained in a full-scale normally operating plant; other information that the industry needs cannot be obtained under these conditions. You have to have special test facilities to get this kind of flexibility of conditions and flexibility of control. We are becoming very much aware of the limitations of testing under full-scale field conditions, but much good information can be obtained this way.

RIGO: The key to getting the type analysis I'm talking about is good models.

BENDERSKY: Good planning.

RIGO: If you've got good planning and good models, the data you collect can be used to validate those models. And as a result you need much less data and in many fewer points throughout the plant. But if you are just going in and blindly taking data--running around monitoring everything and its brother in the plant--you come up at the end with a data set that is of no value to anybody.

BENDERSKY: Agreed. You must start off your test program knowing ahead of time how you are going to use this data or for what purpose the data is to be collected as an ultimate end product, if you will, and not just tests for the sake of general information. When you are first starting any information you gather tends to be useful simply because nobody's gotten any information. This industry is now getting a little more sophisticated, there's more need for specific information, which means that the people who are planning tests and field test programs, in particular, have to give more attention to planning these tests so that the ultimate data is meaningful.

KLEE: Harvey, did you have a comment here?

ALTER: Yes, two please. One, let me make a proposal I was going to raise tomorrow. Maybe it's appropriate now. In agreement with what Dave is saying--we go out and make tests and I think that we ought to make them in the same general format. When we take the data, we ought to within the industry have some kind of agreement, that for example, if you are taking certain data on shredders, that it ought to be taken over the same range of parameters. If we take the data on trommels, it ought to be for the same range of through puts, rotation speeds, hole size, etc.; also, efficiency of separation ought to be measured the same way. Again I would like to raise this tomorrow when it's more appropriate, but what I would like to see come out of this workshop is some follow-up, if maybe it's just ad hoc committees to design formats and tests procedures. In New Orleans, Bill Parker is going to be very active in making these measurements. We would like to share the data with people who follow the same procedures for the measurements. In fact, I'll

even, if necessary, volunteer secretarial effort to make this happen. But there's another way of doing what we are talking about, in addition to field testing. We can scope out on paper, let's say a minimum of three operational sequences. And for these we can start to look for what is the likely related performance characteristics. We can even go into what is the likely cost, if only in pounds of steel required. We can look at the likely power requirement, which you know if you have a shredder for a certain throughput; you may not size the motor exactly right, but you are going to come close to it on judgment. For these we can go further and say what is the likely mass or materials balance through that sequence. I think there are enough data in the literature to make some pretty good guesses, especially if people agree to the same criteria. This sort of approach leads, then, to what are the performance objectives of the components? For example, if the sequence says we are going to trommel and then shred and then air classify, we can guess at what's going into the air classifier and what ought to come out. We can now write down that an air classifier, drawn as a box on paper, has to meet certain performance requirements. We have learned something. For another sequence, there's maybe a different performance objective, hence a different air classifier. This, then, leads to the likely product quality that comes out on the shipping dock. We say, if that's the likely product quality for that sequence, how does it compare with the customer's specifications--which is the ultimate test. If it can't compare, we throw out that sequence. If it comes close, there is a feedback loop as to what has to be changed. What I'm looking for is to fill in the matrix of comparative attributes. I think a lot of that can be done on paper. Now it doesn't necessarily arrive at what might be termed the best sequence. I don't seek superlatives. But what it comes out to is at least some information in the literature--I have thought about this, and he has thought about this, and for you who haven't yet, here maybe is a guide. I think if this type of exercise were started today, it would be added to by experience. It would be added to by other investigators, and we'll build a body of knowledge on which to make some decisions.

KLEE: It seems to me that that would be a start at bringing about some order out of chaos. We talked this morning before the break about the end product. With regard to process design, how about the raw material? Do we need more information on quantity and composition? How critical is knowledge of quantity and composition on process design? Is quantity more important than composition? Do they affect particular subsets of system design more than others? Does anyone care to comment on the raw material side of this process design?

HOLLANDER: Harvey just told us about testing all of the subsystems for their performance. Unless you relate it to the feedstock coming in, that information is of no value at all. And the data must be reproducible. Having a snap piece of data here and a snap piece of data there is what we've been suffering with because of the EPA programs when they first started, whether it's air pollution or water pollution or whatever. We don't have enough data for them to establish criteria as to what is acceptable or what is unacceptable. Now the ASTM group is trying to develop a set of standards based on reproducible data. One of the biggest gripes is that so much

uncorrelated data that has been published--is it credible merely because it's a government publication? Therefore, if we are going to embark on a test program, we have to at least come up with a semblance of steady state conditions and say o.k. under these conditions, with this feedstock, this is what happens. Just testing the back end of a classifier without knowing what the raw material was to begin with is not telling us very much. If we are striving for a cookbook, we are never going to get one. The object of this whole meeting, as I understand it, is research and development and demonstration, not generating a cookbook of design. Is that correct sir?

KLEE: Yes, this is an EPA ORD-sponsored meeting.

ALTER: There are two aspects here. Of course Herb is right. Any materials balance starts with what's going in the first step. What I was talking about before is that I think we can start on paper before getting to the actual measurement. For those of you who haven't made these sorts of separation measurements on refuse, it is lengthy, time consuming, and back breaking. It's 20 minutes of work operating and two days of hand picking, at the minimum. You operate a pilot plant for one day and you are down for--let's guess--a week, two weeks, trying to organize your thoughts as to what you did. But some of this can start on paper. If we only get some scattered points, hopefully better than that as Herb says, we can at least test them against the judgment and refine the judgment. We also, I think, can make first judgments on paper for some reasonable ranges of feedstock. What's reasonable? You go look to these same government reports, and you say, well, the steel varies from x to y so we will make our judgments from x to y. And hope that somewhere there is an average household with an average housewife and an average garbage.

WALTER: Let me tell you that as an engineer who does some structural design, one of the first things I must know before I design anything is what is going into it. We are completing an assessment of European systems that illustrates the point. There are some towns in the world that designed plants based on an assumed quantity of trash. In one instance they designed three furnaces for 8-1/2 tons per hour. However, they find that they can put 10 tons per hour through each furnace, and they find the third furnace isn't even necessary, in fact the third furnace is making their process uneconomical. Another city designed a plant for a heating value that allegedly was lower than what they are actually receiving, and they find they never can get all the trash they've got through that specific furnace. It leads back to one thing, that if you don't know what you are putting into it, you can never design it. I think we cannot overemphasize the need for people to know what they are going to put in these things, and I submit to you that right now we don't know.

JOENSEN: Listening to a lot of the comments in regard to the performance of the process plant, likewise the power plant, I guess I would have to draw an analogy. When you design an electronic system and match components together, you look for the frequency response of your overall system. I think that we have the same objective here. There is no way without a large expenditure of

capital that we're going to identify the material going in, so I think coming back to your outline in Session 1, that what we have to do is really look at the response of each piece of equipment, and say within the scope of the composition of that material, how does that particular piece of equipment perform? Then the system designer says, based on what I have, I can predict the performance over a range, because I think designing for one material spec may not be the right approach and I think perhaps we should discuss it. We look at the end product and say, what is the range of composition that the boiler can handle if we wish to perform it? I think the main point here is we look for one composition of material, looking at the Ames plant, when Arnie Chantland puts in a set of hammers he gets a fine quality material, but two months later we have a degradation. So the cost tradeoff is, do we want to change it and maybe we can sustain the performance over that wide range of composition material because the end product still satisfies it. Otherwise, coming back to this idea of material composition, that will require a tremendous amount of testing, and so it's the subsystem that has to give this performance over a spectrum of material. I think that is the only way you can design a system.

KLEE: What was Ames' experience, Al? You know they designed for something like 200 tons, and I presume some sort of composition. Was Ames disappointed? Maybe Arnie Chantland could also comment.

JOENSEN: I think I'd rather let Arnie discuss that first.

KLEE: Were you surprised? Were there some expectations that didn't measure up?

CHANTLAND: In dealing with solid waste, one of the aspects of this type of material is that it is the most non-homogeneous material. This whole aspect of variability, it ranges from day to day, and from season to season particularly. In spring of the year, you have high moisture content and you're dealing with all these parameters of change, the output material or end product, also changes to some degree. It may be finer, coarser, or it may be higher in moisture content, it may be one which will compact more or less, this type of thing. Did we have some surprises? Obviously we had some surprises in the operation, but I would have to say that we had a lot of good experiences too. Nothing has been mentioned about the firing on spreader stoker type boilers, or some of the problems in dealing with the variability in the sizing. Of course, some of our problems are the equipment itself. Let me give you an example. We found ourselves in the situation where we reverted from double stage shredding to single stage shredding. We were burning on spreader stokers, and we knew this was not as sensitive to fire as the suspension powered boilers. We decided that here was an opportunity for a larger material. They had always told us that they could stand coarser material, so we would send them some coarser material. At the same time we quickly found out that other systems were not capable of handling coarser shredded materials, such as the air classifier and the pneumatic conveyors, air locks, and so forth. So we quickly had to revert back to the smaller type material. I think there are a lot of good things going on

and there is a lot of need for improvement. I think we can find this improvement in the systems. Something that has already been mentioned here, I'd have to take exception that there's no difference in the dual shredding. The reason that I'd take the exception is that I think the reasons you'll go to more than one shredding stage is that you're going to do something in between stages. If you're not going to do anything in the middle, then I'd agree that probably you're spending the same amount of energy, but if you are going to do some breakdown shredding, you'll have an opportunity to do some operations before fine shredding.

KLEE: I simply summarized some of these findings, but I don't want to misrepresent. All I talked about was the same energy output to get to either a given particle size or size distribution. Obviously with two shredders you've got an in-between there that you can do quite a bit with. I'd like to ask one more question. Arnie, you've had some experience now at Ames. You are looking at composition from day to day, and you're looking at quantity day to day. Would you, if you knew then what you know now about quantity and composition, have changed the process design in any substantive way?

CHANTLAND: I think probably the greatest thing that we would have worked harder on--we worked on it some but finally gave it up--was extracting more of the objectionable materials between stages because what we are looking for is an end product--that is, non-combustible materials as early in the stage as possible and practical. I guess in our particular system I would have to say that more would have been done between the two stages of shredding.

KLEE: Thank you. Don?

WALTER: I'd like to ask Arnie if he would share with the group their experience firing the suspension boiler, and then I'd like to make a point.

CHANTLAND: Don, I'd like to refer to the people who have been doing the testings on those boilers, either Al Joensen or Doug Fiscus.

JOENSEN: The question addresses itself to the firing of RDF in suspension fired boilers. Under the EPA grant administered by Carlton Wiles on my right, we have not done any formal testing on a suspension fired unit. We did do a practice burn last week to learn what happens as far as how much material falls down at the bottom hopper. The only comment I could make--again it's a single burn--is that you do get material falling down. Right now we have people drying it and analyzing it for composition and size. At that time we can identify a little more as to what the problem is concerned. Now the city last year tried to burn refuse in the suspension fired unit. Their own experience as given to me is the sluice water necessary to remove it from the bottom hopper increases because the sluicing time is doubled. As far as the quality of the product, exactly what's happening, we don't know because we haven't tested it. So these are really the only remarks I can make at this time.

KLEE: Maybe Arnold would have a rejoinder here.

CHANTLAND: I thought the question also pertained to what was firing on the other boiler. Are you interested, Don, in the spreader stokers too?

WALTER: You see very much earlier there was a comment made that the most attractive person to use this fuel is the utility. I submit to you he is not. He's superficially attractive because he's big, and he's there, and he can take all of the product, but he's firing in a suspension fired boiler. The heavier combustibles are going through that suspension fired boiler into the ash pit, they're not being utilized. Second, he is very intelligent, so he secured long term, low cost fuel supplies, and therefore the price you can receive for your product from him is lower. Third, he is very conservative. His sole purpose for being is to make electricity, and even where we have found people who control both the electrical production and the trash disposal, the guys making the electricity don't want that fuel. So I begin to wonder if maybe we aren't looking at the wrong target, that the right target is the smaller industrial boiler who has the spreader stoker, who has higher fuel cost now, who therefore will pay more for RDF, who probably is a little more daring, a little less conservative. I just wonder if, really, the statement that the ultimate user is always the utility is not really wrong. Then there are also a lot more industrial boilers, so you can start now having competition for your fuel.

KLEE: That's a very good point. Bud Fay actually made that statement this morning; so Bud, you will have to take the heat for that. I was wondering when someone was going to remonstrate with that, because a lot of our own research in EPA deals with the small stoker-fired boiler that may be better for industrial use than utility use. Floyd, do you have something germane about this particular subject?

HASSELRIIS: I want to agree with that point, for the moment, that that's the big problem. The utility is always telling us how they buy the coal for nothing and they want to compare our fuel product on that level. The small consumer, definitely, the small boiler, industrial boiler, has to pay full price for fuel--the regular market price--and he is the best customer from that standpoint. We can even pretty well estimate the future fuel costs for him, because that is part of a known process, as much as we know about it, so we can project and capitalize to sell fuel to that type of customer with much greater reliability. The point I wanted to bring up before--the question of sharing information and type of research that's needed and what's the right way to access to it. I want to take the position of a producer who has a proprietary process and doesn't want too many people coming in his plant to see the proprietary part. Yet he has information which could be useful to other people. He's perfectly willing to divulge it; however, he doesn't want to bring in a government agency to obtain that, nor a research agency which might spread some other information around that he wouldn't like. He might like to generate that information himself and offer it to the outside, provided there's a vehicle for it by which he can retain the proprietary nature of his business and at the same time make that information useful to other people on a standard basis.

Harvey mentioned the question of how to put it on a standard basis so that when we interpret the information we all mean the same thing by it. Which means that it goes through a standard laboratory procedure, and therefore we understand what the outcome is. Now we have made some use of the Bureau of Mines facilities for testing fuels, the combustion of fuels, and the consequences of combustion. This has made it possible for us to look at the total chemical constituents of refuse-derived fuels--all the minerals, and compare all of the minerals in a refuse-derived fuel with, for instance, coal or lignite. Now by using a government testing laboratory as the place we go to get some information, we find that the information we got is now compared on a universal standard. That's very, very useful. In other words, their method of testing with other fuels as compared to our fuel shows how we related on a universal standard. And that's something we are willing to do and it's valuable to everybody. So this is one avenue I think, that can be greatly--where we can help everybody--is to encourage some of the government laboratories that do standard work, and of course that can be private laboratories too, I don't want to offend all of the private laboratories here. What we are looking at is a standard procedure, whereby if you have tested for mineral content everybody knows it is the same procedure and the mineral contents are reproducible. This kind of information as to the mineral contents of these fuels is important all the way through the process. The process of making, preparing the fuel has some influence on the outcome. The input, where the refuse came from, has a great deal of influence on the outcome and ultimately the combustion, what it does to a boiler, and what and how difficult it is to collect it is very, very important and relates to the mineral content. The mineral content, some minerals, are fine, are inherent, and have certain characteristics. There has been a great deal of research done on this subject in coal, and I think that a parallel, many parallel studies can be made. The same methods that you use to test coal can be used to test refuse-derived fuel and you have a universal comparison. That has the utility of pointing out to people that they've been living for centuries with coal with all kinds of hidden and surprising elements in it, and refuse-derived fuel is not that different. Therefore they don't have to be afraid of the smoke that comes from a refuse-derived fuel boiler, because they've always had coal, and we're going to have a lot of coal in the future. That is one area that I think the type of cooperation and sharing of information can be very valuable.

PURCELL: I'd like to follow up on that very important point. I think either the corporate secrecy question or proprietary information areas certainly are quite vital. As we all know, we are in the midst now of a new energy crisis and I suppose it's all so much with us that we haven't even mentioned it explicitly this morning. Of course this conference's effort can go about resolving some of our energy problems. Certainly the whole problem of proprietary information, holding back of data, trade secrecy has certainly beleaguered the whole energy and environmental problems. There are accusations of do we have shortages, if we do, what are they, etc. Is the technology there in the environmental field of toxic substances? Problems have been greatly aggravated by inhibition of information flow

in proprietary information work. The Kepone example is probably the most outstanding in that respect of where the conflict between withholding the proprietary information and who should know what brought about a very serious and tragic problem. So I would certainly like to emphasize that if this proprietary information flow problem is as significant as it seems to be from the discussion this morning, one of the things that should come out of this meeting might be some sort of resolution as to how to go about improving mechanisms for sharing information or at least an ad hoc group that might work on this at a later time. I think it's a very important problem.

WARE: I would like, if I may, to steer this session back to a topic which was brought up earlier, and that is of specific component design, most particularly materials handling, because it's something that interests me most of all. I was responsible for the design and the construction and the startup of the San Diego plant. It was the area where I found we were most hurting and that most other people didn't have a whole lot individually to offer. Within that area of materials handling I'd like to start by discussing the shredding system. Roger brought up earlier something which quite amazed me, in that he had found that shredders blow air down. The City of San Diego, before us, found quite the opposite and in our unit we have indeed found the same thing--that shredders in fact blow back towards the feed. We explained this by the fact that the hammers going down are carrying material with them, the hammers coming up have nothing between them, and therefore bring air back. Whatever the cause, and whatever the end result, obviously between the Bureau of Mines and ourselves there is a difference. I think it is something that is worth discussing, when you start talking about shredders. Going back to the manufacturer, we identified the problem, we went to American Pulverizer and said, we think the shredder will blow air, tell us how much. They knew nothing about it, they were unable to help us, they were unable to tell us how much air. So we again had to come up with a design which we could live with and use it to generate data at a later date. We have a large recirculating system on our shredder, which dumps something like 15,000 cubic feet a minute against the flow. We circulate it back into the shredder to eliminate dust flowing everywhere, I think this is something I found in almost every other plant I visited; dust in the shredding area is probably the most obnoxious, the least pleasing, the most significant problem found in other plants. By recirculating the dust and by applying a vacuum system to the shredder whereby we draw off some of the air, we've been able to maintain a very clean shredding area. So I would like to suggest that we would proceed from now on discussing specific components, and the problems that have arisen in our experience, and our anticipated ones.

SPENCER: Regarding that blowback problem, I think Roger's shredder is very different than your shredder in that he has a flail mill with two rotors that's drawing the material down, and so the blow-through problem that he incurred that caused him to add a skim classifier is very different than the blowback problem that you have in a down-running shredder. Following up on the same point that you made, I think that every company would probably have

the same feelings that we do regarding proprietary aspects. You spend a lot of money developing information that you don't particularly want to share with others. I think some of the work, for example, that Waste Management and NCR is doing is very worthwhile. It's very disappointing to me that the Federal government doesn't support that kind of activity, and my hat's off to private companies who, for example, will sacrifice the operation by adding two different kinds of shredders, making their inventory problems more complex, knowing, certainly, that one's going to be worse than the other, but not knowing which is best. Frankly I can't understand why the government or why somebody isn't funding basic unit operations development. Greg Rigo was talking earlier about trying to develop a system model. Well, we can't even model a single unit operation, so how can we even proceed to even look at how to model an entire system when we don't know anything about the elements of it. I look at air classification for a moment, we've got about 10 different kinds of air classifiers. I have yet to see some good data that when you pull 60 percent as of lights, how clean is your light fraction, how dirty is your heavy fraction? Everybody talks about 80 percent lights. Well, we can pull 100 percent lights, we can pull zero percent lights. How good is it? It's very disappointing that there isn't comparative data being developed, like Waste Management is developing. I can't understand why a private company will necessarily spend its assets to develop that kind of information and then divulge that information to the public with no apparent benefit to itself. Frankly, I think that a government testing facility should be developed that allows comparison of one unit operation against another. Let's take air classification where we shred the different sizes, where you shred it 3 inches, 6 inches, 8 inches, and 12 inches, and you classify at 60 percent lights, 50 percent, 40 percent, and look at the light fraction to see what's in it. Measure the operating data, measure the power consumed, and so forth and then try a different air classifier and see what that is. Then you go back to evaluating the system, and you say o.k., in Wisconsin Electric or in St. Louis where we've got huge 300 megawatt boilers, we can use a low quality air classified product and we'll take just about anything we want. Dave Klumb's very happy to take anything you want to feed into it, and as Ed Wisely was saying, for a while they didn't care if they had the cans or not. In our facility at Monroe County we are dealing with 40 megawatt units where we need a particularly clean combustible product, and there is no basic information that allows a comparison of one air classifier to another. So a company spends hundreds and hundreds of thousands of dollars developing things to meet its particular problems, and yet the next time you come up against a new problem, and you wind up having to spend all that money over again to look at a new way to solve some different system problem. I think it's a responsibility that should be a shared responsibility through government funding. I think these demonstration programs have been pooh-pooed by EPA. I think they are very worthwhile; the fact that there are failures is very beneficial. I think it's important that before a community makes a major investment into a system that they don't walk into it blind. I think these problems that have come up have been beneficial. Just to say that companies ought to take all the responsibility here, or individual companies should, and not share the

responsibility among many companies or many communities through Federal funding, I think, is a mistake. Frankly, I think that the Federal government has really dropped the ball here. When you compare the development with, let's say a missile system, to the development of resource recovery, you are really operating in the Dark Ages. In developing missile systems, the government funds the research and development and then forces their people into that information, collects the data themselves, and then forces it on to the competition in order for competitive bidding. They found that that makes the lowest cost system to the eventual user, which is the taxpayer. I think the system that we are looking at right now of having private companies invest at much higher interest rates than the Federal government can and the waste that goes with developing the same information through private companies over and over again and then passing that off to taxpayers through tipping fees is a mistake, and I think you've really dropped the ball.

KLEE: I'd like to get a hundred copies of those remarks! Carlton, did you have something to say?

WILES: Would he like to send those comments to the congressional committees and so forth that control appropriations?

KLEE: I think everyone knows that even though he's criticizing the government decision here, what he's really saying is that EPA should be better funded; more funds should be provided by government for these purposes.

SPENCER: I've seen the requests, and EPA hasn't requested any outlandish amounts of money from the government. You can't do the job if you haven't got the money and you haven't got the resources. They don't seem to be requesting it.

SPENCER: Look at the last congressional hearings and look at the people who were selected. I don't know who selects or who goes to those things, but certainly, for example, somebody interested in mass burning is surely going to say that technology is here because his competitive edge is the fact that he is old and you are new. If you look at university professors, you have to scratch your head sometimes and wonder if they are tied down to this earth. You bring these people into a congressional hearing, and you put some titles behind them and some nice universities, and people become impressed by what they are saying when they are not even associated with the realities of the problem. I have the feeling it's an education problem, but it's one that we shouldn't be sitting around here trying to get Raytheon to tell Arthur D. Little what we are doing, and vice versa, because it's not going to happen. On the other hand, if you make it attractive to us we might do it. You've got to find the method to make it attractive. In the meantime, we have to be profitable and we have to justify the expenses that we are making which have to be made in order to continue development. The only way you can do that is to show a payoff somewhere down the road. You're not going to get that when you are giving the information that you just paid for to your competition.

KLEE: Steve, we haven't heard from you for a while.

LINGLE: I would like to respond to the problem that Dave Spencer just discussed in terms of private firms giving up information they've developed with their own funds and also regarding the comments made about evaluating new facilities which are coming on-line. We recognize the value of evaluating new commercial plants that are coming on-line, and EPA is developing a program to do that. Based on discussions that we've had already with some of the companies who are involved in the building of these systems (and in some cases they own them as well), it's clear that they are very reluctant to have a private contractor funded by the Federal government come in there and collect a lot of detailed information on their system. The reason is very simple. Sure, there's a need to get information out, and I'm sure that most companies would like to share information to the extent possible, but there is that very real business issue of giving up competitive edge. Now there's been a lot of discussion about the value of evaluating existing systems, but the extent to which that can be useful is going to depend on the extent to which the firms can allow us to collect detailed information on systems. I understand the problem. If I were in the private sector I'd be reluctant myself to give up information on how a proprietary air classifier or some other piece of equipment performs. Does anybody have any suggestions as to how we can overcome this situation?

SPENCER: First off, I think it's a mistake to try to evaluate systems at this stage of the game where we haven't even got the information with respect to evaluation of the unit operations, and therefore anything that you do with respect to evaluating the system will be useless. The second thing is, by its very nature you can't evaluate a unit operation unless you literally destroy the operation in a sense. You can't not disturb an operation and still test the range of five different feed sizes and six different light and heavy fractions. It has to be a test and evaluation program. You can't walk into a running system that its lifeblood is moving waste through a site, and start screwing around with the equipment and yet if you don't screw around with the equipment, you'll never get the essential data that's necessary to understand the unit operation. If you don't understand the unit operation, you'll never understand the system; you'll never be able to model that system.

WARE: I'd like to address myself to the point that has been brought up. To give the EPA some credit, our particular plant at San Diego is indeed partially funded by the government to the extent of four million dollars. Above and beyond that they're letting, or just have let, another contract for some half million dollars for an independent contractor to evaluate the plant throughout the demonstration year. The net result of that will be that everything we've done during the test, everything we've done during the year, will be public knowledge. There's the tradeoff, we've put some of our money into it, some eight million dollars, which really for us is expensive advertising. The County of San Diego has put some money in it, as a gesture I guess, and they will benefit from it to some extent, possibly

getting their money back. The Federal government has put money into it, they have assisted us in our development, and in return all the information that we generate will become public. We don't feel we are losing our competitive edge because of it; in fact we feel it may well enhance our position, because everything we've done will be publicized--the things we've done right and the things we've done wrong and most important of all what will be publicized is how we went about it. We feel that a year from now, regardless of the competitive technologies, the things that municipalities are going to buy will be expertise, management skills; they won't be buying a process, because by that time, a year or two from now, most of the processes will be highly refined; they will be most competitive; consumers and customers will be buying the company with its management abilities and its development skills. As I say, the EPA programs do exist. I don't know how many more are envisaged, but they've certainly assisted us, and the end result will be public knowledge and sharing of information. The contractor will come in, he will have access to everything we do. Now there may be things in my head and the head of our maintenance superintendent that we don't talk about, but a sharp contractor will be able to pick out everything we have ever done and why, and publicize it, so we end up divulging everything we do, to the benefit of everybody, but not to lessening our competitive edge. I believe to answer Raytheon's problem, it is happening in some cases. Now whether it should be extended or not, that's another question altogether.

BENDERSKY: I think this discussion is very valid with respect to the future of this industry as far as the various test programs that are going on. I think we have to differentiate, and I think I see the pattern coming about here. Testing an individual system (a la El Cajon or St. Louis or something like that) is valid for that system and that system only. You'll get all the information you want about that particular system. Where I think it's been lacking so far, and I would like to see and I hope that the direction will go that way, is that these tests will have a commonality to them, so that we can evolve comparative data which will be useful to somebody who wants to design a new system--not the one at El Cajon, and not the one in St. Louis, and not the one at Ames. What we need to do is plan some of these plant test programs so that the data then becomes comparable and useful for future systems, and not just the evaluation of that particular plant alone.

RIGO: Dave, back on the concept of how you go about getting this data, I agree with you wholeheartedly that if we could set up individual unit operations, control the inputs to them on a series of controlled experiments, that we are going to get a fantastic amount of data in a very straightforward manner. That is the ideal, and I feel that if the EPA or DoD or somebody comes up with a good pilot plant, we can get a tremendous amount of information this way. In fact, probably this is the only way to do it. However, I believe there is a second approach which makes a lot of sense, and this is with systems analysis coupled with design procedures, or models. You rely upon the dynamics of the normal variability of the input refuse and

the normal changes in just operating that plant to establish the range of plant operations. If you are monitoring all the outputs you can then back into what the transfer functions for the individual components have to look like. That is the second approach for getting this type of data. It is one that is not widely used because it is much more difficult. It requires a tremendous amount of analysis, as opposed to a tremendous amount of data acquisition. Given that, there are plants available today that we can probably get our hands on if we promise to stay on the outside and not interfere with operations, compared to waiting even if Dave Berg could come up with money to build this massive pilot plant next week, we're looking at three years, four years before it is on-stream. We can do a lot of work from the plant we're working in today and get some handle on the transfer functions now. We should validate them with the type of experiment you're calling for in the future.

KLEE: Dave brought up the matter of a pilot plant, and we haven't heard from representatives of the armed services today. I know that Steve Hurley of the Navy has some thoughts about a pilot plant. Would I be embarrassing you, Steve, to say a few remarks about this?

HURLEY: I'd like to make some comments along those lines and they're general comments, but I was thinking they fit more into Session 4 than they do at this point. However, I come to this table with a certain experience, and as every moment goes on I'm more happy that I'm here, because I think there are some people here who have been struggling with the problem for a number of years now and have reached a certain frustration, while there are others of us who are new to the problem and would like to utilize your experience--or play leap frog research, if you will--so that we can bring about changes to the existing solid waste systems that I think we could agree to are necessary. I think that if there is a premise to the workshop, it seems to be jelling in my mind that it goes something like this: That changes to the existing system, to existing systems that we operate today must take place, and we haven't defined yet or we're dealing with the problem of how those changes should come about. We need to know more, first of all, about what that waste stream is, because we didn't need to know that much to operating existing systems. Second of all, I think it's important that we do indeed get the funds that we are able to justify, working at what I call the field level or at the place where the problems exist. To that extent I think it's interesting to note that DoD put out an instruction called resource recovery three years ago in which the word was that we were all going to proceed vigorously. It didn't take long for people to realize that you couldn't proceed vigorously based on the information and state of the art. Today the same instruction has been reissued, and I have to speak for the Navy, which I represent. We've been able to muster a million dollars, and it's our intent to get the money spent as close to the problem as possible. That means to me that you spend your money at a field activity working on an actual waste stream in order to demonstrate how you can go from the existing system to whatever it is you propose to do. And that to me has the distinct advantage of drawing anyone who wants to come down and see the advantages and the costs of changing--the advantages of pro-

ducing a usable material or recovering whatever it is, fuel or otherwise. So that to me is part of the situation as I see it. I think the discussion is getting better every moment I hear.

RYDER: That comment, if I'm reading Mr. Rigo right and Mr. Spencer perhaps or the other gentlemen over there, about possibly getting some 25 million dollars or any number, whatever number you pick, and build a pilot plant as Mr. Rigo correctly stated--I should say understated--in getting in the line of three years, it will take four to five (that's only up to the testing stage) and so, the pilot plant of what? What system are you going to make a pilot plant of? We've got a number of different systems, a number of different ideas, that's my point, you've got pilot plants all over the country, so build up from that point.

KLEE: Well, maybe we ought to let Dave Spencer reply to that since this is rather specific.

SPENCER: I don't think the objective would be to build a pilot plant or a system. That's exactly what we've been doing, which is not the way to go. I think that the information that is lacking is the unit operation information, and what we've got now are too many systems that we can't compare to each other on any kind of uniform basis. That's not to underestimate the problems associated with getting, with three years or five years, but at some point in time somebody is going to have to do this if we are going to make sensible decisions regarding the selection of unit operations for any system, whatever one it is. The other thing that concerns me here is, when I hear about the Navy putting up a million dollars, I kind of say, big deal. That's very little compared to what communities are putting up in terms of 50 million. If that's the best the government can do, good luck.

KLEE: In a sense this discussion is really more germane to Session 4 tomorrow afternoon. Now back to the process, the system process design, if we can. Is there someone who would like to get back to the subject here?

POWERS: I'd like to make a comment on that. Herb, I think, hit it on the head when he said we are not really trying to design a cookbook plant; each plant has to be designed specifically for its requirements. The waste that is generated in New Orleans is entirely different than the waste that is generated in Buffalo, New York--seasonally, geographically, and whatever way you want to evaluate it. Whether we can do an RDF operation at our particular place as to some other place in the country, or whether we should go methane or what, we don't really know. So you can't design a cookbook plant. It has to be in the location and it has to be as a local operation. So that's particularly what I have to say, as far as this goes.

BURCKLE: I don't think the objective is to come up with any kind of a cookbook plant or a standard plant that will fit everyone in the nation. I think what we are really concerned about is to determine the underlying principles of this design, which would include how the equipment performs,

the equipment model, the unit operation model, and the system models that are optional alternatives to getting to different types of end products based on the types of feed material coming into the plant. Now, cellulose is cellulose, and that's basically what we're looking at when we are talking about a fuel. Every community generates varying quantities of this material seasonally, and it's contaminated with different kinds of inerts, which we want to pull out in recovery. When we talk about composition of solid waste from the municipal sector, we are really talking about a quantity of cellulose coming in, we're talking about a quantity of metals coming in, we're talking about a quantity of glass coming in, that's where the composition enters in. We're talking about all of these things as though we can look at them as separate streams, although they are really and truly mixed at the inlet side, and the question is how do you separate these things? I think the underlying principles are going to be pretty much the same from city to city, but translating those into use in a given city is where you get into the differences.

LAMB: We're talking about quantity and composition. My own thoughts on that are quite strongly that I don't really care what the composition of refuse is, because even if one does a lot of studies on it and comes up with averages, the day-to-day variations are so large as to pale them into insignificance. It is very important to know the quantity. There have been some disappointing surprises therein. For example, at East Bridgewater we got less than we thought from the communities, if you look at the historical statistical data on generation rates. I think, however, the principal reason that the quantity is so vital, is that when you enter into a contract with one of these municipalities, you want a "put or pay" contract. There will be a lot of discussion over what amount is going to be put or paid for, and it's really with that information that you can then decide what size the plant has to be and what the costs are going to be. So I would put a much higher priority on quantity generation information than I would on composition.

HOLLANDER: Where the economics on other than the fuel fraction is contingent for the viability of the plant, you have to know something more than just what the cellulosic fraction is. You should know what the cellulosic fraction is and the mineral fraction.

LAMB: But I would say, Herb, if your basic economics are, for example, a specific composition of metal, you're in trouble already. That's an extremely high risk venture.

HOLLANDER: I agree, Tom.

BURCKLE: Based on those two comments, that is why we have to look at waste, not as a mixed fraction total amount coming in, because on the other end your economics say you're signing contracts to produce a certain amount of product in each of the categories on the outlet end of the system, which says that what you are really doing is, what is my average or base quantity

of cellulose coming into the plant that I can recover as a fuel product. What is my average or base quantity of aluminum coming into this plant that I can recover and sell as a product on the output? I think those from the compositional standpoint are the important points that you have to consider on your economic side, because your economics are dependent as much on your products that you are selling as it is on the tip charge that you are charging with total quantity coming into the plant.

H. FREEMAN: I'd like to ask some of the systems designers--those of you who represent that element of our group--how much do you really use these generational studies that we put out so many of, as far as across the board generation of refuse in the average town when it comes down to the design of these systems you are bidding on. I guess I'll direct that to Mr. Lamb of ADL. Do you use them at all, or do you go out and run another study?

LAMB: On the work we've done, we haven't really paid a lot of attention to composition data. We use the national averages to more or less forecast the financial model. Because the compositional data is going to be variable any way, I don't know what kind of a program one would propose to get a representative sample. Am I going to sample all of the wastes for a year; am I going to spot sample it for a week, and if it's a week, is it going to be the summer or the winter or spring or the fall? I think we are more concerned about generation rates, and there I guess, we rely principally on historical data from the communities and that's frequently lacking. Where this weakness in our experience has ultimately shown up is when it comes time to draw up the contract and to state the quantities that are going to be put or paid you'll see a lot of backstepping, saying, we know we are going to give you 1,500 tons and we want the dumping fee based on 1,500 tons, but we'll guarantee you eight. We know there's going to be a percent and a half of aluminum, we've heard aluminum's worth \$500 a ton, and we know that it's going to be worth \$9 in the refuse, and we want that for a credit, but if there's only 3/10 of one percent aluminum in the refuse, well, we are going to be disappointed. We the systems suppliers accept that risk, not the community. So I think it gets difficult in the compositional thing, because you have no control over it. For example, legislation might become active like a bottle bill or container bill that would influence the composition. You have to deal with these issues in the contract and allow for ranges, because I think it's unreasonable for either the systems supplier or for the municipality to make concrete promises which they can't meet because that's either going to drive the system supplier into bankruptcy or make the contract at great expense. There has to be flexibility there. I don't know what other systems suppliers do, but we don't do a lot of compositional work; we focus principally on quantities rather than composition.

ALTER: We are all talking about a bandwidth problem. We have an average--EPA publishes a national average, your city publishes it--they freeze one day of two weeks in a year and say this is the composition, this is the quantity. We all know it's wrong, but we all like the warm feeling in the breast by having a single number. I think that the only outlet, the only

solution to this problem, is not to sit around here and talk about it and worry about how much it is, but at least for the time being, handle it contractually; it becomes a legal-institutional matter and not technical. The engineer still has to design for the bandwidth, not for the single point. One example, here in New Orleans the contract talks about the plant and the tip fees are based on an asserted single composition, a "baseline composition." But the contract also says by the end of the year the parties will sit down and adjust the tip fee up or down based on the operating experience of the plant. The year following, they will readjust and so forth. This is the only fair way of handling changes in composition because the operator--even if it's the municipality has to avoid bankruptcy. We can't predict very well. We can go to all of the generation studies and it doesn't tell what will happen two years hence if Campbell's soup is no longer packed in a steel can but in a plastic pouch. I think what we are talking about here is the ability or the needs or the demand that a system be designed for an average plus or minus on the bandwidth, and that contractually the tip fee (or whatever the method of payment) is adjusted according to experience.

KLEE: Gentlemen, this session ends at 12:30 and I intend to end on time. As the chairman's prerogative, I'll take the last 3-1/2 minutes myself to sum up briefly. We've had a lot of discussions on a lot of different items. There seem to be two items receiving the most importance, and they were at the antipodes of any process design; more specifically, what goes in and what goes out. We had most of our discussion on the specification for fuels--how tight it should be or how loose. We've had as much or more discussion on the quantity and/or composition of the incoming material (especially the quantity) which affects process design as well. Now there were some items that came up that were discussed and identified as problem areas, areas in which information needed to be developed more; certainly materials handling and scale-up were mentioned. On more than one occasion it was reiterated that there are many, many variables in system design, too many to produce a simple handbook. One can't paint by the numbers here, although there was some suggestion that perhaps we could generalize into a smaller subset to create some order from the chaos. There was some discussion about the ultimate use of the fuel--utility versus the industrial or smaller user. There was quite a bit of discussion about proprietary information and funding. We started the discussion with a consideration of four questions. Dave Berg summarized our answers this morning. However, it's not a particularly positive list, because there are a lot of "No's" here. Let's look at them one by one. The first question was: With the technology available today, can we produce a suitable product which the consumer considers a useful and desirable fuel? That was Part A of that question. It appears that the consensus is mostly "No" at this point in time. The second part of that question was: Are specifications for the fuel product available? Again, in the main, there's a lot more work to be done too. We'd have to answer somewhat negative on that. The second question was: Is adequate information available to the implementer or

investor for selection from competing commercial and developmental systems? It looks like kind of a "No" on that one too! The third question was: Is there an alternative process concept offering a potential for significant improvements in product quality, economic performance or both over the present practice of primary shred and air classification? Well, certainly no one suggested that there was a panacea--that there was a better flow chart. Evidently we just don't understand the problem well enough to make a blanket statement like that; there are so many variables and we recognize that there's no way in the world you are going to come out with the answer with regard to such sequencing. The fourth question is: Is adequate information available to the systems supplier or consulting engineer to perform the process of design with sufficient confidence to offer performance guarantees? Definitely there was a big "No" here. Although in general we've answered these questions negatively, it doesn't mean to say that there isn't some information available in regard to each one of these questions. It does seem to me from the discussion we had this morning, that we do need more information to design more efficient systems, and we do need more information to make selections of what we already have. Although to keep on time I'll have to declare this session closed, we can continue our private conversations during lunch. Thank you very much.

SESSION 2: SELECTION OF EQUIPMENT

Stephan Lingle, Moderator

LINGLE: Session 2 deals with selection of equipment. I think this gives us an opportunity to move from the discussion we had this morning, which I think was beginning to yield some good results, into discussions of specific problems. Maybe we can start to get some more specific directions in terms of what EPA or others should be doing in the way of R/D&D to solve these problems. We're going to focus this discussion on individual equipment items. I'd like to use as a starter the breakdown that Harvey Alter suggested this morning in terms of breaking the different materials unit operations up into materials handling, separation, and size reduction. In discussing each of these, I think we should keep in mind the discussion items which are listed in the agenda for the session, which was sent out earlier. The suggested issues we should be thinking about regarding individual equipment items are such things as the equipment performance data; the experience that we have with existing equipment; capital and operating costs; guarantees; scale-up factors; effects of changes in the incoming waste stream (we touched on that a little bit this morning); different types of waste, besides municipal wastes, that we might include; scale of operations in terms of large versus small cities; and so forth. Keep those factors in mind in discussing the individual equipment items, and I think we can focus on some of the problems that we have with these types of equipment, and some of the real needs for R/D&D. I think to start this off I'd like to ask Dave Bendersky to give us a rundown of the study that they did and some of the suggestions that they came up with for research development and demonstration, and then I'd like to go back and start on the materials handling. Dave, can you comment?

BENDERSKY: In our program, as I mentioned earlier this morning, we broke the various so-called preprocessing equipment down into 12 categories, which are listed on page 10 of this handout that we passed out this morning. [See page 69]. Starting, if you will, at the beginning of the plant with receiving facilities and listing a few of the items that are involved in receiving facilities and going on down to conveyors, shredders, magnetic separators, air classifiers, and so on. What we were looking for in our study was the missing information in these areas. What are the research needs? I must tell you that we found research needs in all of these areas. Generally speaking, the area that has received the most attention so far is shredders, and in spite of the effort today on shredders, there's still a number of unanswered questions. There's a number of basic missing data. People like Trezek and other people have done laboratory tests on shredders. Quite a few shredders are out in the field (the last count that I had was over a hundred shredders) that are actually operating on MSW. What we are not getting yet is full-scale operating experience reported in the literature. Everybody is essentially learning through their own efforts. The basic data that's needed by people who have to either design shredders or design systems--there is still quite a bit of missing information. I don't know if this is the time to be very specific about the types of missing information, but basic-

ally technical and economic data is still missing as far as we can determine, for example, the proper maintenance schedule for a shredder. Most people are retipping the hammers when they wear, but they retip them at different time scales. [It ranges] all the way from every day retipping, some every week, some a month, and some just let them wear out and change the hammers. The question is: What is the most economical procedure, what should be done from a cost-effectiveness standpoint? We don't find this data yet.

PREPROCESSING EQUIPMENT USED IN WASTE-TO-ENERGY SYSTEMS

1. Receiving facilities (S)
 - a. Scales
 - b. Building
 - c. Loaders
 - d. Ancillary equipment
2. Conveyors (S)
 - a. Flight
 - b. Belt
 - c. Vibratory
 - d. Pneumatic
3. Shredders (U)
 - a. Hammermills - vertical, horizontal
 - b. Grinders - roller, disc-mill
 - c. Flail mill
 - d. Wet pulp
 - e. Ball mill
 - f. Knife mill
4. Magnetic Separators (U)
 - a. Belt type
 - b. Drum type
5. Air Classifiers (U)
 - a. Straight
 - b. Zigzag
 - c. Vibrating
 - d. Drum
 - e. Concentric
6. Screens (U)
 - a. Trommel
 - b. Vibrating-reciprocating and gyrating
 - c. Disc
7. Dryers (U)
 - a. Drum-type
 - b. Fluid-bed
8. Densifiers (U)
 - a. Pelletizers
 - b. Briquetters
 - c. Cubers
 - d. Extruders

9. Storage and Retrieval Systems (S)
10. Process Control Systems (S)
11. Dust Control Systems (S)
 - a. Cyclones
 - b. Baghouses
12. Fire and Explosion Control Systems (S)

(U) = Unit equipment.

(S) = Supplemental equipment.

Source: "Study of Preprocessing Equipment for Waste-to-Energy Systems: Summary Material and Research Needs," Midwest Research Institute for Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, February 1977.

We have serious problems in so far as the safety of operation of shredders, which hasn't been addressed properly, at least in the literature, yet. All of the shredder manufacturers that we contacted are very concerned about the hazards of running shredders on MSW. Frankly, they are keeping their fingers crossed, hoping that nobody gets killed before real solutions to these problems are found. People are trying to avoid the problem, trying to pick out the dynamite and the other obvious things that might be in there. But things will and do get through. There have been fires, there have been explosions, and there hasn't been enough attention paid to this particular area. Operating costs--there are some scattered data here and there; it's hard to compare one set of costs against another because accounting procedures are different. In many cases people are keeping cost data on systems and not on individual pieces of equipment, so it's hard to ascertain whether one type of shredder is more economic than another. Or even basic questions, like is a horizontal hammermill better or worse than a vertical hammermill. Basic questions like this haven't really been nailed down yet. Now that's in an area that (as I said earlier) most people have done the most work in, and it leaves the rest of them with even less basic information. For example, receiving facilities--what is the best layout for a receiving facility? What's the truck traffic pattern; what's the best way to go? Should it be dumped on the floor and then pushed by a front end loader into a conveyor, should it be put into a pit, should it have hydraulic rams in it? These are questions that haven't really been addressed on a comparative basis; individually yes, each system and each system designer has considered these problems, but it's not in the literature, it's not really available to the industry. Conveyors have been around a long time, used for all sorts of things, but MSW is a unique problem. Some of the characteristics, for example, of MSW that have been studied--composition, etc.--are fine, but it doesn't answer questions that the conveyor people ask. Compaction, angle of repose, and other characteristics of MSW are not readily available. Magnetic separators have been around a long time. Simple units were used initially; they were

found to be somewhat lacking; they do pull out some of the magnetic material, but the quality of the product has been questionable. There has been some redesign by the manufacturers of magnetic separators in order to design their equipment more specifically for MSW. However, there's only been a couple of years experience so far, and again the field data isn't as complete as it should be. For example, although you get reports on the percentage of metal being recovered, they don't usually give you the amount of metal that was in the raw waste, so you don't get an efficiency factor of the magnetic separator. Furthermore, you don't often get the quality of the recovered ferrous metal, in other words, how much nonferrous metal is in there. Air classifiers were already discussed to some extent this morning. There is no good comparative data between the various types of air classifiers--which is best, which is most efficient? We don't have the data, at least we were not able to find it. I can go on down through the list that way indicating specific areas of need. I would like to point out a couple of areas that have almost totally been ignored in the literature, and that is process control. This has sort of been a black box that each of the systems have, but they haven't been reported. Some of them are very simple, some of them are very complex. Should the system have a very sophisticated control system, should it be automatic, or should it be mostly manual? These questions are not answered readily right now. Everybody has their own opinion, but there isn't good comparative data yet. Incidentally, a lot of this information is considered proprietary by the designers of the control systems. Dust control is something that hasn't been reported. It's being used more, I'm glad to say; it has been sort of ignored in the past. There are more dust controls now on systems, but their effectiveness has not yet been determined, again, primarily because there just hasn't been enough experience. So these are some of the areas that we have found very lacking in so far as basic data that almost everybody in the industry would like to have, but it just doesn't exist yet.

LINGLE: Thank you, Dave. If you look on page 10 of the MRI report [page 69], let me just make the following sort of organizational suggestion. I'd like to break these different unit operations down into the areas that I mentioned before, and maybe you can just put a little note by each one of these. I think that the first two are materials handling issues, and Number 9 is a materials handling issue. I think Numbers 3 and 12 are size reduction issues. [Numbers] 4, 5, and 6 are separation questions. Ten and 11 and 12 we can classify possibly as process control. Then 7 and 8 are additional processing or something along those lines. I'm bringing this up just so we can organize the discussion. I would like to start with the materials handling issue. Within that I'd like to pose a question: Do we have a single adequate means of storing and retrieving shredded solid waste? I would postulate that we don't. I think the means that has been designed in most systems, which is the Atlas storage system, frankly is not working well in some cases. I think we need some improvements, and I'd like to start off by asking for some comments on that.

CHANTLAND: I might say that I don't believe that the Atlas system is a total failure. It does provide a storage facility; it does provide a means of unloading the facility with equipment that is not buried within the waste stream. There are times when mechanical problems do exist, but I think you are going to have that in almost any type of equipment. I will say one thing about its limitations, from our experience at least. It is limited to handling only the fine ground material. This was another part of our little test. We are going to send over the larger material to the spreader stoker boilers and it will not go through an Atlas bin. It really isn't designed to handle larger material.

LINGLE: When you say larger material, what size range are you talking about?

CHANTLAND: Maybe 3 to 4 inch. I would say in general it has to be less than 2 inches in size.

RIGO: Steve, as people are addressing the storage question, let me get Arnold to shed some light onto the problems of spontaneous combustion when storing chopped garbage. Have you been able to develop any rules for determining detention time, depth of storage, moisture, or anything else where you start looking at it and being concerned?

CHANTLAND: I don't believe we have any real data on this area. We do have some procedures. One of the procedures is that we expect if at all possible to empty the bin once per week. We have, however, had the material in the bin for as high as three weeks, without any spontaneous combustion. There's only two things that we are concerned about there. One, of course, was possibility of some spontaneous combustion; the other thing is, we know that due to the moisture and oxygen present, there is going to be a breakdown of that material and there's going to be a Btu loss as it sits there. So it is important that this material be used in an early stage and as it is produced.

FUNK: I worked with Arnold in the design of the Ames plant, and we faced a decision of coming up with a storage and retrieval system quite a few years ago. Your remark that it just doesn't work, I disagree with totally. There had been some cases where there had been some problems with it, but based from the designer's standpoint, when it comes to the selection of equipment, we had this decision to make and we had the opportunity to view all of the Atlas systems as well as all of the other systems that were in operation, and we selected the Atlas. For what it's designed for it works very well. If I had to make the decision again today from what I've been able to observe, it would probably be that one. I think that's further enforced by the fact that Americology made that decision, the designers of the Chicago system made that decision. I would just like to turn it around; where has there been one besides the Hamilton, Ontario plant that doesn't work?

LINGLE: Baltimore.

FUNK: Now has that been the Atlas system itself? Now all of these stories about explosions and having a D8 Cat hook onto the chain drag and drag it out--they are not the fault of the Atlas system.

LINGLE: Well, no, it's been the Atlas itself that's failed in Baltimore. Maybe the distinction we need to make there--and I really pose the statement that it doesn't work to stimulate comment--is maybe it's the size of the material. In Baltimore you have a larger size material; it's not a small material, and Arnold mentioned that it perhaps does work on smaller size material. In Baltimore the material is larger. The feed rate has not been uniform, the material has solidified in the Atlas, and this is a problem that I've heard other people talk about. Regardless of size of material, you just can't store for any length of time in an Atlas or any storage system. They've had significant wear problems in the floor of the Atlas in Baltimore. The concrete is just wearing out, and there's got to be some solution to that. Perhaps other people would like to comment in more detail on some of the problems or successes that have been experienced with the Atlas system or other systems.

WISELY: I think that there's a misconception, really, of the function or at least of the combined function of the so-called Atlas system. One of the main advantages of a system of that type is that it can both retrieve in various streams as well as perform a certain degree of storage. One of the principles which has become fairly obvious in essentially every application of shredded waste is that storage, if possible, should be avoided. This is just a statement of fact. The Atlas system, I think, is being used merely because it's the best of any of the available systems at the moment. I don't personally regard it as a failure. I agree with Harvey on that; that it's just a matter of the lesser the various available evils. The principle that I think some of the smarter designers are trying to get into now is to store the material in such a way that it can be unloaded from vehicles, more than anything else--actually store it in vehicles. Up to a certain limit, this is a more economical method of storage than anything else. There is also the possibility that you get a certain amount of metering out of the vehicles, not very accurate, but to a certain degree. The idea of using an Atlas bin, I think, has been somewhat misused, because instead of trying to use it as a distributor they have been using it for storage. I think in some of the newer installations, I believe in Milwaukee, for example, that the same principle is being incorporated as intended in St. Louis, to use the material only for a very limited amount of storage, for only say a few hours, with the idea that the principle function of the Atlas bin would be purely as a distributor.

RIGO: In the study we just finished up for the Navy Civil Engineering Laboratory, while performing tradeoffs we asked the question: What happens if we want storage and we go to d-RDF plus some kind of conventional bunker or silo system versus going with an Atlas bin that is capable of giving you two or three days surge (looking at weekend capacity principally)? Based

upon extremely shaky data on the cost of producing the d-RDF, and based upon a series of assumptions on how you can handle the material, it looks like the d-RDF plus conventional silo storage is roughly the same cost as storing it loose because of the huge cost of the shredded waste storage bin. I am throwing that observation out for what it's worth, recognizing that it's preliminary.

FUNK: The biggest areas of concern I see with the Atlas bin: one, it's a high energy user, and I think that's something we should address in all of these storage systems, is look at how much energy we are actually using for each function in all of these things we are looking at here. I think that's a disadvantage. This floor wearing out--that's something to be handled in design. As Mr. Wisely was pointing out, I think there's a lot of merit in using this as a retrieval system or distributing system--a metering system--which is essential for feeding certain types of burning equipment. That's where we always get into our flap. I've got roughly in the neighborhood of about 15 guys working on various designs, and every one of them come up with a new and unique area in the way of handling this solid waste into storage and out of storage. When it gets down to the final decision it gets back to: Has it been demonstrated? Our clients are not necessarily in research and development, and has it been demonstrated? The Atlas system certainly has had more successful demonstrations than not, and of all of the available systems, I would say that it has to be ranked at the top. As far as economics, we've gone through many evaluations where we put it into bulk storage and used some kind of a bulk or front loader to move it into a smaller distributing system; and when you shank out the economics, once again it gets to be about a toss-up. What you've done is, you've tied up usually more man-power, and that's the thing most of our clients would like to avoid and stay away from that man-power usage.

WARE: I think it's appropriate to describe our system for the benefit of those of you who aren't familiar with it and the way we came about deciding upon it. We receive our material on the floor directly dumped from trucks, and feed it as fast as we can and as soon as it's received into the shredder, and from there it's distributed onto the floor of the building--simply dumped onto a concrete floor with a rotating conveyor. We store about 450 tons there. We have stored it as long as 8 weeks with no problems, no severe odor, no fire hazard. From storage, obviously, there is a need to meter into the rest of the plant. We store, incidentally, because the rest of our plant runs 24 hours, where we receive only 8 hours. So we recover from our pile of garbage with a front end loader and feed it into a unique piece of equipment, which is the heart of our front end process, called a doffing roll bin. This bin has sufficient capacity to absorb the surges resulting from using a front end loader. It holds around 1,000 cubic feet. From that bin the material is then metered by variable flow control into our air classifier. We went with the bulk storage on the floor because the material we were handling is shredded, very similar to Baltimore. At the time when we were designing, they were having troubles and we didn't want to commit to an Atlas. So storage on the floor posed no problems for us, recovery is easy using a Bobcat or similar machine, and as I say, this is

all complemented by using this doffing roll bin. The bin itself is borrowed from the paper industry. It's a rectangular bin with a live bottom. The material is fed in at the top, and it travels horizontally. The pile builds up to a certain height, where it's leveled with screws, and the conveyors across the bottom of the bin move the entire pile together. There you have no feeding problems, normally associated with live bottoms; the entire pile moves horizontally into a series of rollers with teeth on them. These rollers are arranged in a near vertical row (actually diagonal), and as the pile moves into the rollers, the teeth on the rollers pick the material off of the piles, roll it overhead and down into a conveyor. We have only demonstrated this thing for a thousand tons but we have found no discernable problems with it. So by a combination of the refuse storage on the floor and the metering bin, we are able to store, reclaim, and meter, without any appreciable problems. The capital cost, I would venture to say, was about half of the equivalent Atlas bin.

RYDER: I'd like to throw in my experience with the Atlas bin. Some gentleman over there said the City of Chicago had selected Atlas because we thought it was best. Well, that isn't quite true. We don't select people; we don't look over the whole spectrum of people and say, we like you. We have to go out for bids and all other things being equal, must select the low bidder. We had heard the same horror stories about Atlas bins--they get plugged up and they have to dynamite the refuse out of it, and other kinds of stories, but we did not disqualify Atlas from bidding as we felt that they had one of the most workable systems on the market and we were protected, as our specifications included a full contract value performance bond. We had to reject the bids twice before we got a successful bidder. Either the bids far exceeded our estimates or the equipment did not meet our specifications. The third time around, the low bidder was sufficiently close to our estimate and agreed to meet our specifications. At this moment, the construction of the bins is nearing completion. We have two Atlas bins--one about 60,000 cubic feet and the other about 90,000 cubic feet, or about 300 tons capacity in one and 450 tons in the other. Tonnage, by the way, is difficult to figure because of the varying unit weight of the refuse. Part of the difficulty with other manufacturers meeting our specifications was that we required that the feed rate from each conveyor leaving the silo to be variable. This will allow the utility to regulate the flow of RDF to each of the four boiler ports. Only Atlas seemed to be able to come up with a viable system to do this. In any event, there is a performance specification that the contractor must meet. They must not only be able to retrieve the RDF at the specified rates, they must be able to store it. So if there's any problem with storage or operation, it's going to be with the contractor. He is going to have to answer for it.

SPENCER: Is your performance contract directly with the construction contractor, or is it with Atlas?

RYDER: It's with the general contractor; Atlas is the subcontractor.

SPENCER: And your general has the responsibility for just that particular item of equipment. Does he have responsibility for foundations?

RYDER: The entire contract runs about 4-1/2 million, and he is bonded to the tune of 4-1/2 million.

SPENCER: O.K. so the whole receiving facility is 4-1/2 million with the single general contractor?

RYDER: Yes.

SPENCER: And all the others like electrical, structural are subs to him?

RYDER: Yes, that's correct.

JOENSEN: One comment I would like to add (Bill referred to it now) is that when we talk about a storage and retrieval system, I feel some adequate mass weighing system for control purposes into the boiler should be considered part of that system. Ames has a volume flow, the City of Chicago has an impact plate position below the bottom of the in-feed conveyor. I don't know what Milwaukee has, but in terms of the operation of the boiler, not only am I concerned about the specification of the quality of the product, but an adequate retrieval to indicate the flow rate. Doug Fiscus and I have looked at a belt system used on Atlas bin, and we feel that should be strongly considered. It's a more positive weighing system for control purposes.

LINGLE: Let me see if there's a consensus here, in terms of the need, particularly for the Federal government to conduct development on storage systems. Is the feeling that the systems we have are at least adequate and that it really isn't high priority for the Federal government to either try to improve them or better them, or do you think that there is a need for some specific research programs in this area, and if so what are they?

FUNK: While we're talking about these storage and retrieval systems, let me just throw my comments in on this. We're talking about people that are ready and willing to commit today; we're talking about this as a long-term venture, all the things that we are doing here. I definitely think there are better ways of storing and retrieving. I just unfortunately haven't been able to think of them myself, or I'd probably go in business. I think there are a couple of suppliers that are offering new types of systems, and they are a combination of different things. What Occidental just described is something that's been demonstrated in several different cases, and I think that has a lot of promise. We can't forget also that we're talking about a specific need, and that's firing in a combustion unit that has to have a controlled rate of firing. There are other applications, such as intro-pyrolysis, where this fine control or supposedly fine control isn't necessary. In that case you can consider some other. So there's a place I

think that research would help: identify the combustion processes or conversion processes, I should say, that and what their feed rate requirements are. That could be something that could be identified for the industry, and there certainly could be some research or at least some study given to that point. Then perhaps some type of program to monitor the cost, the actual operating cost of the existing installations, and especially if some of these new ones get installed, so they can be compared against the Atlas. In the business that we are in, we have to rely on the equipment suppliers for information if it isn't available from any other source. Now we had the job of sorting out what is true and what isn't true and then you have to make comparisons, and usually they put it on such a basis you can't make comparisons. You realize that going to look at things that are in question and talking to the operators and piece that with the suppliers' information to come up with your answers. One of the things that we've been toying with within our firm is to put together a designer's handbook, that tells about a lot of the things that are on this page of MRI's report. In other words, getting into conveyors or anything else, tell them what angle of repose you can have, or what angle of incline you can have on them, how fast they can run, what type works better than others. The same is true in storage systems--discuss the pros and cons. This type of information could go into a handbook that I think could be of merit to the entire industry.

ALTER: You asked about research. Those of us who have worked with various processes and fractions of refuse, particularly the organic fraction, have all experienced the material bridges and hang-up easily. It doesn't flow down chutes all the time; it stores oddly, as has been discussed. A good deal of research is needed in the materials handling. We know through art, we learn through art, that a chute or a bin has to be shaped a certain way and then maybe the material won't hang-up. But there is no guidance doing this; it is all empirical. There is not even a systematic approach to solve the problem through art. You try it, it works, and you stop work. There may be a better way of doing it, but you stop work because the partial solution may be good enough. I think this has to be taken the next few steps, people's experiences have to be recorded, or somebody has to approach the learning process in a more sophisticated way. Before doing so, you have to learn to describe the material and its flow properties. We don't know how to do so.

HATHAWAY: I disagree with Harvey on one standpoint. The rigorous theory of design and flow for the design of storage and flow facilities for pumped solids was developed in the fifties at the University of Utah. The procedures for designing storage facilities, feeders, and some certain types of conveying apparatus are relatively straightforward, and unfortunately known by a select few. Our lab is looking into this. The things that we don't know are the mechanical properties of RDF coming out of the various unit operations. Some research ought to be done in this area.

ALTER: So we don't disagree. As I said, we need measurements of these properties. We don't even have to know how to describe the materials so we don't know how to apply the theory. I'm sorry to hear that the art and the science of materials handling has been kept such a big secret. Maybe some of the research is finding out where it's been kept a secret.

LINGLE: O.K., does anyone have any other comments on materials handling problems, conveyors, receiving systems, or anything of the like?

LAMB: On the practical side, the biggest problems I see with the conveyors are the spillage and belt cleaning problems. We need good skirts. We need ways to clean the belts to make sure that we can control spillage because this results first, in a housekeeping problem, and then in a fire and explosion control problem. And we have several types of conveyors in the plant that we are now operating and none of them have adequate skirts and spillage is a very large problem. In describing its flow properties, I think I can describe it in a word, it won't. That's a very good rule to learn about municipal solid waste, particularly the shredded organic fractions thereof: they simply do not flow, and you must diverge, don't converge.

ALTER: Little story out of our pilot plant. For a while as a general rule, all conveyors had self-cleaning head pulleys--something we learned from the scrap industry. But then we found two things. One, if the material was too much like gravel (I'll call it that), but even organic, we found that the self-cleaning head pulley would cause the material to dance, and then the performance of the entire conveyor belt design changes. We replaced pulleys. Two, we found that a self-cleaning head pulley is not good enough in that there appears to be some sort of relationship between its diameter and the self-cleaning ability for a given feedstock. This is particularly true, we found, on air classifier heavy fraction, because it contains rags which hang-up on some sizes of pulleys and not others. There's no design guidance here; it's a question of trial and error. These are the sorts of things I think have to be recorded so that the experiences can be shared. The design handbook, Harvey, I think is going to be a narrative for the first edition.

RIGO: On those problems you are pointing to, if you get a particularly dry load of material, for example, a pure shot of cardboard or wood chips, what would normally go up a conveyor at a fairly shallow angle of incline, will not go up it any more. Vista Fiber and Chemical Company had an experiment using a tree sprayer that pumped water out at the rate of about a gallon for every 10 tons. The dry material tended to go up. Just coming out with some design guidance on mixed municipal waste is not enough if you have a plant with the probability or likelihood of getting industrial waste, which comes back to compositional guidance. You are going to have conveyors that work for 90 percent of your material but won't work for 10 percent. There has to be some way of accounting for this, either a general design or some kind of attenuating system that can be cut in and out.

WISELY: Just for the benefit of those of you who have not heard of this phenomenon, I think that you should be aware that if you install a vibrating conveyor with a certain frequency and stroke in a pit, you are going to have a little trouble. As some of you may know, in the initial installation at St. Louis we had a really magnificent piece of equipment that

was designed for a variable stroke but a constant frequency, that was designed to accommodate from zero up to about 60 tons an hour of raw waste. It really worked, except that the frequency was a direct multiple of the natural frequency of the building height and the building width, and this was accentuated by the fact that it was within a pit. There was no way of predicting this. We had this analyzed afterwards, but there was no way of predicting this in advance. For goodness sake, don't put a thing like that in a pit.

CHANTLAND: One of the problems mentioned was the problem of skirts. I would like to add one other problem, and that is the drop of materials from one conveyor to the other. When it drops out of the shredder onto the conveyor, and the conveyor drops on to another conveyor, a certain component of the grind is going to be a dust fraction, and whenever it drops, the air picks it up from the hopper, and as material goes down, air has to come out.

SPENCER: After air classification, do you find that that also is a problem?

CHANTLAND: In our particular case the light particle is no longer exposed, so we are dealing with the heavy fraction after air classification, and there is only a small amount of dust, and in our case I would say most of it is associated with the bypass screen on the air classifier. You do get some fine particles coming through this screen, which is trying to take out the fine glass on the air classifier.

LAMB: Dave, we find dust at every transfer point, either before or after. You don't elutriate the dust, if that's the question to which you are alluding in the air classifier, at least that hasn't been our experience. We have not elutriated the dust, and then had a dust-free operation at subsequent transfer points.

POWERS: I'd like to make one observation we had in building Recovery 1. The thing that I've found, in almost every instance every piece of equipment that we use in refuse handling has been bastardized from some other piece of equipment. The shredders were originally designed for something else; the conveyors were not designed for MSW; all these pieces of equipment are retrofitted, massaged around, and put on the shelf and called a standard piece of garbage equipment by the industry. I think that if we can get the industry to start designing equipment specifically for refuse processing, that would be a big step.

BENDERSKY: The industry, in some cases by our contacts with them, are willing, in some cases anxious, to improve their equipment. Unfortunately, however, they don't always get all of the information back that they need to improve their equipment. I said earlier this morning I think there has to be more of an interchange of information between users of equipment and manufacturers of the equipment, etc. I would, incidentally, propose for

EPA and perhaps for some others a suggestion for a conference of some kind in which equipment manufacturers, system designers, system users, have a general get-together, so that there's generally more of an exchange of information. I found a number of equipment manufacturers interested in improving their equipment, and a number already have, specifically for MSW applications.

FUNK: A couple of the manufacturers have started to respond to the solid waste area and have published handbooks or design manuals that are so common to the rest of our industry that have addressed and have [unintelligible] solid waste handbooks. Mayfran is one that has put a book out like this, and they have some rules of thumb about designing. They went around to the industry and looked to see what had been done right, what had been done wrong, and got suggestions from a lot of different designers, and they have listed these. I think that's a step in the right direction. It certainly isn't an answer, and I'm not saying they didn't just take some other piece of equipment they already had and now call it a solid waste-- I'm not saying that, but they have started to put some of this in writing for general distribution to anyone that might want to get a hold of it. They're not the only one. We've got, I think, about three books now and catalogs in our files that have this type of information in it. So I think they are starting to gear up to this thing.

FISCUS: Bob Power's comment was very interesting. It seems that what we've got to date is either pneumatic conveying or belt conveyors. So if you look at starting from scratch designing a system to handle x tons per hour of some sort of shredded material from Point A to Point B, what would you use specifically other than the belt conveyor or a pneumatic conveying line? The reason I asked that, it's a leading question, I get this kind of question bounced off me quite often. People say there is a need for this, and I haven't yet heard some good suggestions. What are some other types of conveying mechanisms that can be used?

POWERS: I can't give you an answer there. I do know that every piece of equipment we have in the plant, we modified. Every one. I can't think of a piece of equipment that has come into that plant that we haven't massaged around, rebuilt, redesigned, sped up, slowed down, we've done something to it to make it work. This is something you can't put in a text book, or in a handbook, you just have to feel it and you have to work it. I think that if we can get the manufacturers to be aware that there is a large, large industry out here that needs good equipment, that needs rugged equipment, they'll start to turn it out. They have apparently made [unintelligible], that's the conveyor. Now the shredders, you know they are interested in automobiles, and rocks, and things like that and not necessarily garbage.

RYDER: I will agree with Bob on that. I think if you were to write a spec today and consult all of the manufacturers as to what you should put in that spec, they would tell you all you need is tell me how many tons per hour you want-- 25, 50, 75 --and we'll give you the equipment to move it, shred it, classify it, or whatever.

LINGLE: Does anyone have any comments on pneumatic systems? There hasn't been too much said about that. That was at least one of the problems that seemed to occur in early RDF systems, the wearing out of the pipes and so forth. I know there have been some pluggage problems, I believe there have at Ames. Would anybody care to comment on pneumatic conveying systems?

CHANTLAND: I would like to make the comment that we do have one pneumatic system for the plant--the Atlas bin--and four pneumatic systems from the Atlas bin to the boilers. Probably one of the big reasons we selected this type of system, was from the dust control standpoint of transporting this from point to point. It's one thing to put up with dust inside of the plant; it's another thing to put up with dust you breathe outside the plant, as we had observed in some installations. Since we sit right in the downtown area and we just couldn't have the type of an operation that wasn't relatively free of dust. We found from the St. Louis experience about wearing out of the elbows. We put in an elbow with a replaceable liner. The liners, of course, will still wear out; that's what they are made to do. The question is really finding an optimum point; how much money you want to spend for a particular liner versus the time span that it will take to wear out. I'm not sure that we totally have that answer yet at this time, but the material itself will move essentially in suspension, and it's only at the corners and the elbows where the material really comes in contact and wears the pipeline. Since this is a pneumatic system, wear also takes place at the air lock feeders. You have to lock this material through one point into the end of the line, and as mentioned before, oversized material can jam air lock feeders, and this is also a point of wear. A certain percentage of the material has to be cut, or separated, as the air lock moves around. This is a wear point, and there are replaceable blades and a certain amount of maintenance that is needed.

SPENCER: Have you considered soft rubber air locks as opposed to the harder Ny-Hard type?

CHANTLAND: We don't have any of that type for the pneumatic system. Now we do have that type on the air classifier and it works very well. We would be very interested in anybody who has the experience with the use of the soft system. I do understand that the newer air locks come out with not only replaceable blades, but they also have a replaceable diagonal vane on the rotor. It also has a replaceable shield or liner.

LINGLE: O.K., one more comment on this, and then I think we ought to move on to the next subject.

JOENSEN: There's been some sweating inside the Atlas bin, and the municipal utility makes it a practice every Monday morning to run the two conveyors that have not been operated the previous week. This cleans out and prevents any solidification. The sweating caused some drifting down into the bottom of the conveyor, and since the grit has a tendency to accumulate on the bottom, there was a sheet of ice formed. By running the two unused

conveyors about once every three or four days, this was a minor operating problem that was solved right away.

LINGLE: Why don't we move on to size reduction now? Perhaps we could start this off by having George Trezek present some of the slides that he has on the work that he's done on shredding.

TREZEK: Before I get into the slides, I would like to preface my remarks by giving a little bit of history of how the project got started. About 1969 there were a few shredder installations which were just being put together. EPA was interested in trying to learn something about how shredders operate; specifically, what governs their performance. I think that all of these machines were really designed for brittle materials, that is, for crushing rocks and these types of things. When you review in the brittle material literature on comminution (a fancy word for size reduction), it turns out that there's a whole host of laws and theories, but when you start dealing with refuse, which is only about 25 percent brittle, you have an entirely different situation. One of the first things I did was to survey the shredding installations at the direction of the project officer at that time. The purpose was to try to obtain comminution data from the existing machines. However, it was very difficult to accomplish this in the field. We decided then to set up one machine in one place in which you could monitor all of the things going in and out, and do a very controlled study. First, it was necessary to ascertain what kind of things we should be trying to measure. Secondly, conduct a series of measurements under controlled input and output conditions. What I'd like to show you today are some of the results that we've obtained over a period of time, and then talk a little bit about some of the kinds of energy loops that you get into when you start arranging processes in different orders. This is the laboratory as it's set up. This, of course, was really not intended to be a size reduction laboratory when we started out. I convinced the University administration to let me use it in order to set up the facilities. The shredder is a 10 ton per hour Gruendler hammermill which according to today's standards is a fairly small machine, but at the time it seemed like it was a fairly reasonable size machine to begin to study. We changed the drive system of this machine to operate at a variable speed, because one of the things we wanted to study was what effect the rotor speed would have on the size distribution of the product that comes out. A belt drive system is used. Normally the motor would be connected to a flexible coupling directly on the shredder shaft. Refuse is loaded with a front end loader. The conveyors are also designed so that we can vary their speed and study the effect of feed rates. This machine, by the way, used to be at the Johnson City Compost Plant, and when that project was phasing out, the EPA decided that we should use it for our studies. Consequently we set it up to run these comminution tests. I might just point out that when we received the machine it was in reasonable shape, but when we tried to replace the hammers, I called the factory one day to ask them how to get the hammer pins out. It wasn't clear how that should happen. We were told you sort of burn them out and then purchase a new set.

Here's basically a conveyor discharge of shredded material. The air classifier is in back; I won't get into that at the moment. Let me summarize what it is we're looking for. What we want to know is: Given an input size distribution, can you predict what the output size distribution will be for a particular set of conditions? Because if you can control the output size distribution, you can then design some other follow on processing equipment. We want this sort of general theory which will describe first the comminution mechanism. Then we'd like to verify the theory with experimental data. We want to be able to predict size distribution. The current literature (this was three years ago) dealt primarily with homogeneous brittle materials, and did not deal with heterogeneous materials like solid waste. Traditionally when you looked at theories that described size reduction, they were of two types, the so-called continuous theories and the discontinuous theories. The continuous theories involve a relation between energy and size, i.e., $\frac{dE}{dx} = - C/x^n$

where E is the net energy required per unit weight in a given process of comminution, x is a factor denoting size, n an exponent, and C an index which depends mathematically upon the unit chosen and physically upon material properties and mill operating variables. However, it is difficult to express "size" in a mathematical form. In any actual process the material being comminuted has a considerable range of size on entering and leaving the process and also it is not possible to denote this size by a single index because of the variations in the shapes of the particles. The three most frequently quoted laws are derived from the above general energy relation. These are attributed to Rittinger, Kirk and Bond, when the exponent n is equal to 2, 1, and 1.5 respectively.

The discontinuous theories, which are the ones that we eventually adopted, are essentially a statistical treatment and involve two things which I will get into a little bit later--things called a breakage function and a selection function. What those come down to are--in any given pass when the material enters the machine, a certain fraction is selected to be broken during that pass; that's the selection function. The breakage function says it will be broken according to some size distribution. This summarizes some of the size distribution relations. These are the Gaudin-Schuhmann equation $Y(x) = (x/k)^\alpha$ which relates the fraction of undersize Y(x) (% passing) to the relative size x/k. In this relationship Y(x) is the cumulative fraction by weight finer than the stated size x, k is a quantity called the size modulus (theoretical maximum size), which together with the slope parameter α characterizes the product. The Gaudin-Meloy size distribution in relation for single fracture has the form

$$Y(x) = 1 - (1 - x/\bar{x}_0)^r$$

where $\bar{x}_0$ is a characteristic dimension of the feed particle before fracture,

r the size ratio which is a measure of the number of breaks in the particle. The most useful size distribution selection for refuse is the Rosin-Rammler equation, i.e.,

$$Y(x) = 1 - \exp[-(x/x_0)^n]$$

where n is a numerical constant and x_0 is a characteristic particle size (the size at 63.2 percent passing). The quantity x_0 is an extremely useful parameter in correlating the comminution parameters. It is important to note that the 63.2 percent passing quantity is obtained by substituting x for x_0 in the above relation, namely,

$$Y = (1 - 1/e) = 0.632$$

Here for example, are some typical size distributions that were obtained for different types of machines with a raw refuse input (Figure 1). The size distribution for raw refuse is shown on the right. Shown are some data taken from our lab which are accumulated at different speeds. They fall into this general band. Here's some data taken out of the Eidel shredder which produces essentially a finer size distribution. Now the idea is to see what we can do with this kind of information. I want you to observe one thing. If you take an input distribution and go through a comminution series of events, this would be the average size distribution that you would see with the machine running at 1200 rpm. We take that same size, and use it as the feed, and run it through the machine one more time to produce this secondary size distribution (Figure 2), which represents a movement toward smaller sizes. The characteristic particle size is smaller, x_0 , which becomes the feed for the secondary shred. We then move to this tertiary system, and you can see there is a diminishing size with each pass. Now the interesting thing here we need to remember is the difference in power consumption which was 12.5 kilowatt-hours for the primary shred (Figure 2). Getting from there to there and regrounding and achieving a smaller x_0 , we expend about 5.6 kilowatt-hours per ton, and so on down the line. That's what I'd like you to remember about this particular data. Here is the same information (Figure 3). What we want to see were how some of the variables affect the kilowatt-hours per ton for power consumption. I must admit there is some scatter in the data, but nonetheless, it was what we found. After a lot of thinking about it, it turns out there does appear to be a minimum power consumption at about 35 percent moisture content. That is interesting because you can optimize where you should run the system. Higher moistures gave greater power consumption. The thing that I think is important to realize here, is that if you are running the machine at 1200 rpm, you would tend to follow the dashed curve (Figure 3). If you are running at 790, you would tend to be following this lower solid curve. For example, at 5 tons per hour, the power consumption difference is approaching 50 percent. You ask, well, that's great but what is the consequence of that? The consequence is that you have produced a particle which has a slightly coarser x_0 or slightly larger x_0 . However,

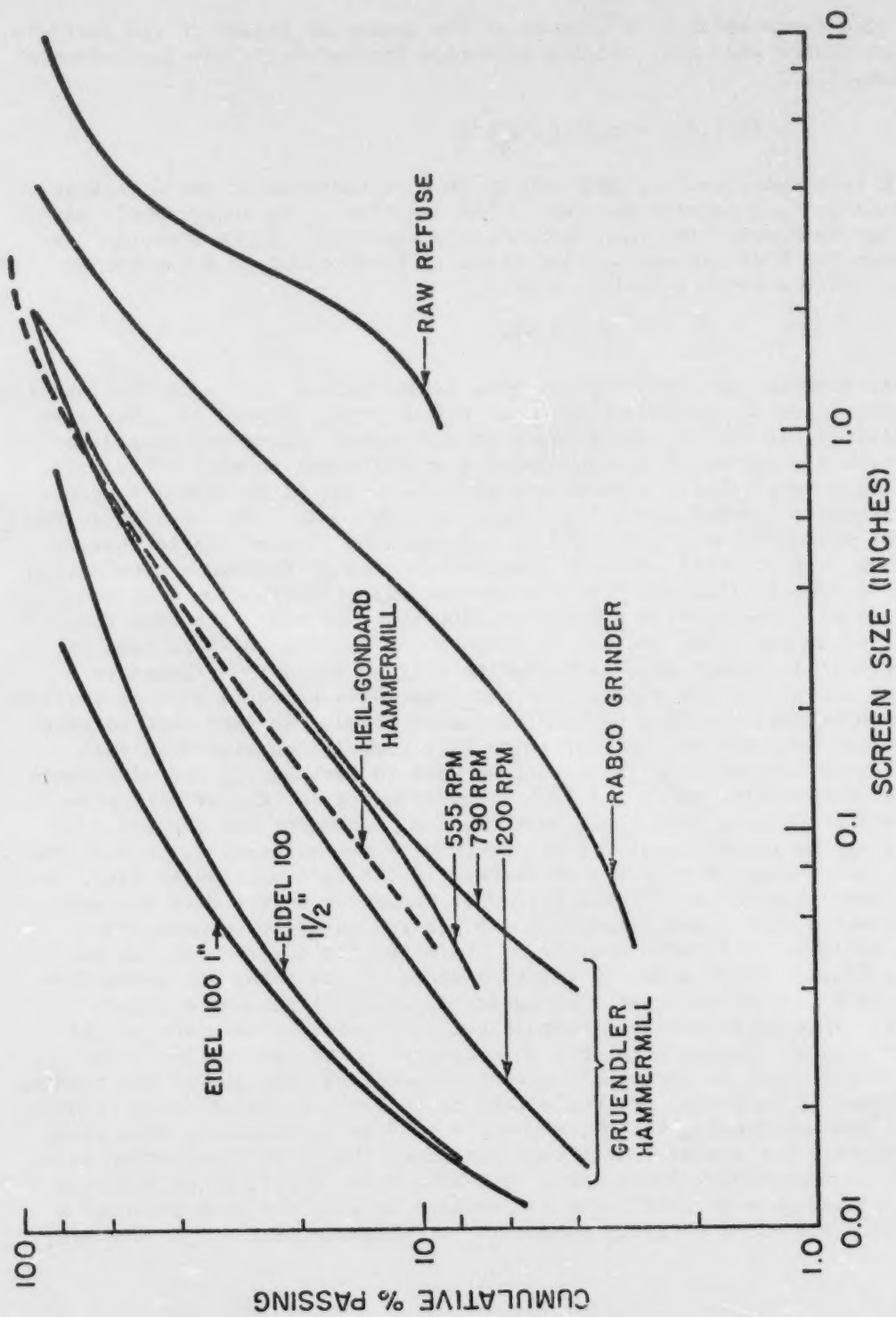


Figure 1

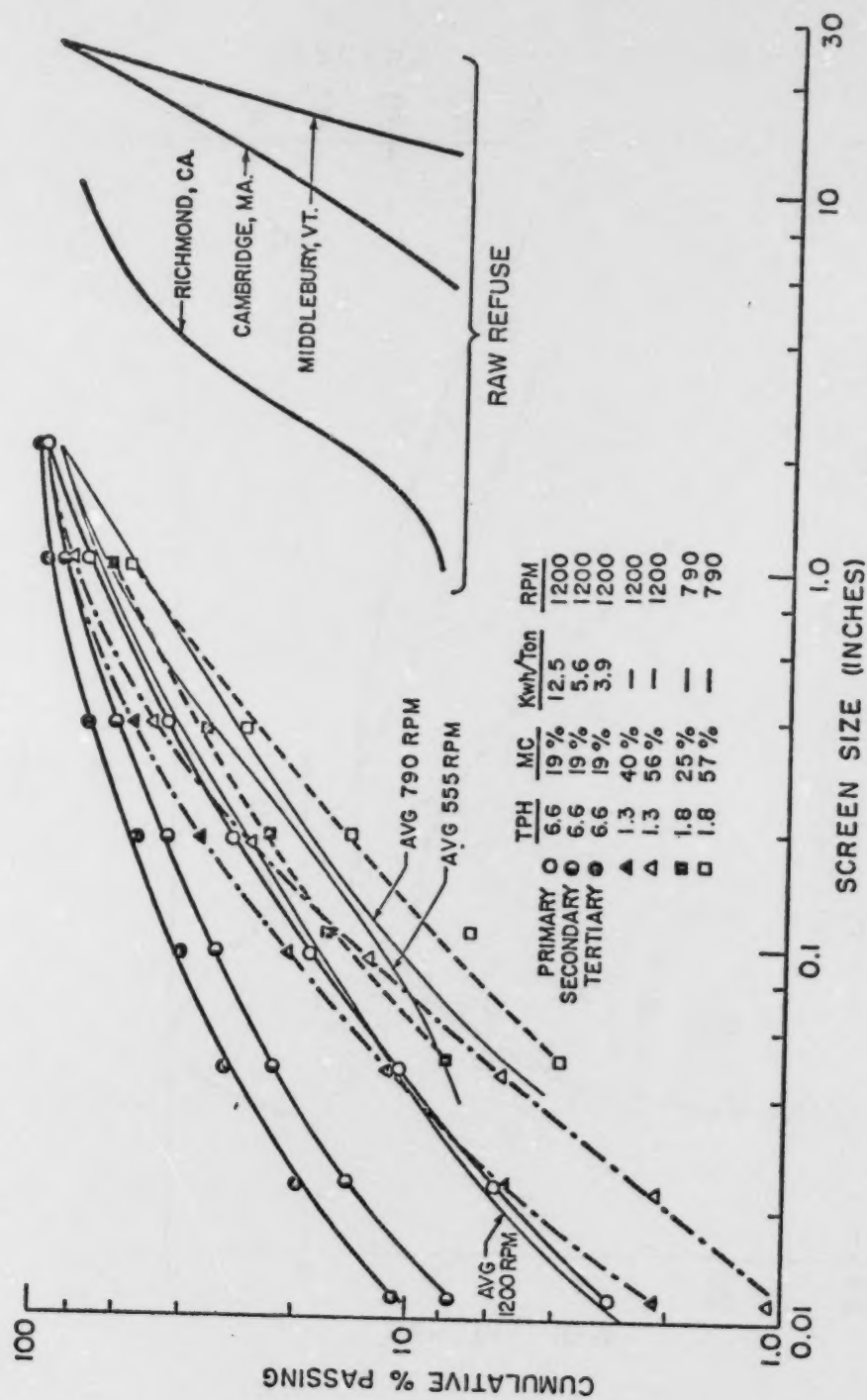


Figure 2

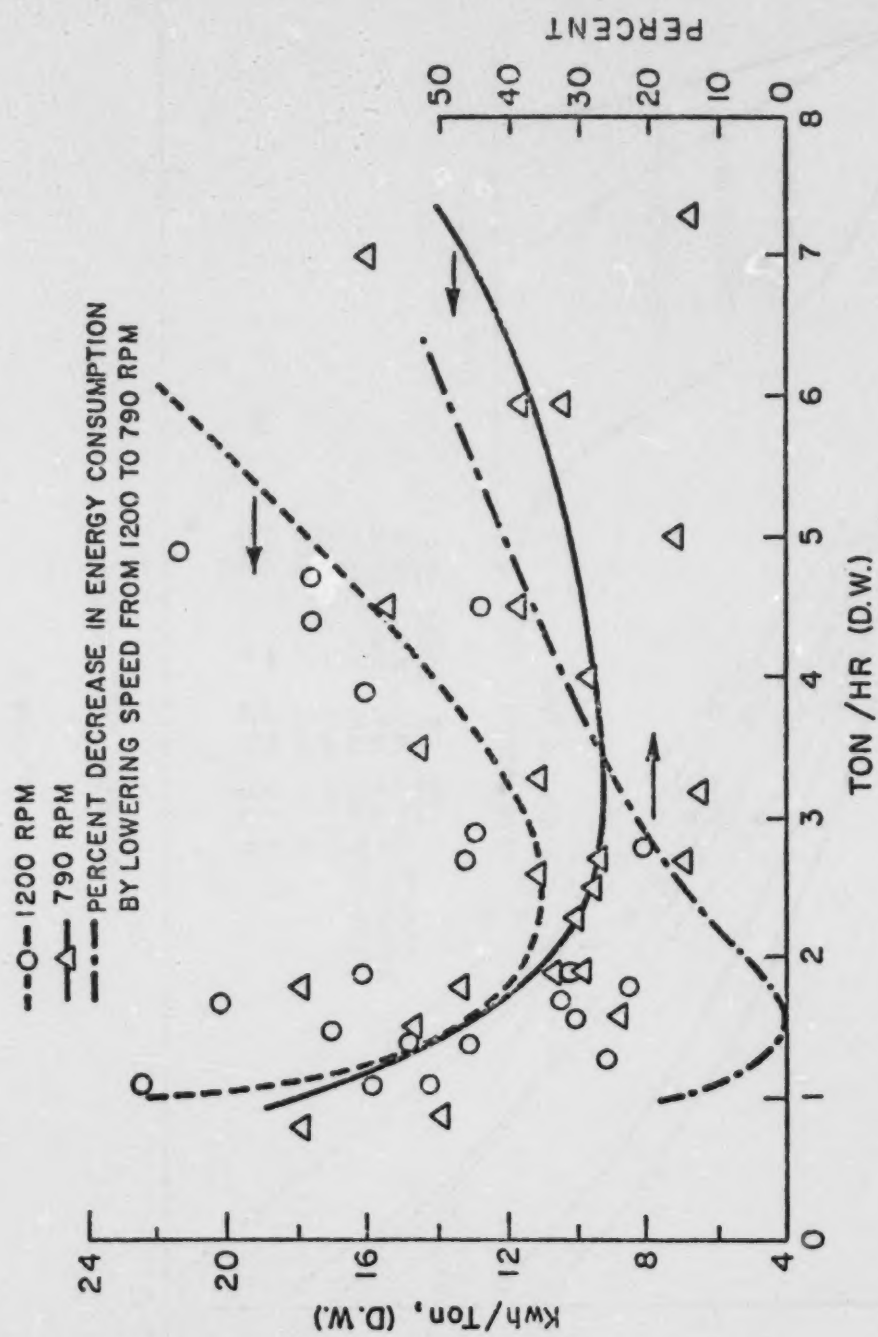


Figure 3

if that material is going to be used in some other process down the line, it doesn't matter, except you can achieve a fairly substantial savings in energy at this point. This (Figure 4) is the specific energy in kilowatt-hours per ton versus the characteristic particle size, x_0 , and interestingly enough the machines tend to fall along a curve. You get some types of shredders giving finer sizes up here; traditional hammermill type machines fall in here; and another type of grinder called the Rabco system falling down here. This kind of information can be correlated against grate spacing, so we get a relation between energy and grate spacing. I might point out, interestingly enough, that when MRI did a study a while back, they took the data from Ames, I believe, and plotted it on this curve and it fell on the curve, which was comforting.

Now let's get into a little bit of modeling that produces the size distribution curves. Basically, all the model says is that you select a certain fraction of the particles to be broken and that represents the selection function. The key is the product that you operate on. There are various sophistications of the model. The simplest is called π breakage, which says the material goes in, a certain fraction is going to be broken in each pass, i.e., in matrix terms, $S = \pi I$ and the equation describing the process is

$$p = \{ \pi B + (1 - \pi) I \} f$$

Here $S(y) = \pi$ for all sizes y ; that is, a proportion π of the particles independent of particle size is broken according to the breakage function $B(x, y)$. The parameter π completely describes the process if B is assumed to be known and is a useful measure of the breakage effected by the process.

The repeated breakage cycle model is also useful. This model depicted by

$$p = \left\{ \prod_{h=1}^N (BS_h + I - S_h) \right\} f$$

describes the situation where the feed and product size distributions do not cover the same sizes, and the size ranges differ considerably. In effect the breakage process is considered as a series of cycles of mild breakage. Here $h = 1, 2, \dots, N$ refers to the h^{th} cycle in which the probability of breakage is S_h .

Two forms of the breakage function were selected as being appropriate for refuse comminution. They are a modified form of Broadbent-Collcolt.

$$B(x, x_0) = \left\{ 1 - \exp \left[- \left(\frac{x}{x_0} \right)^n \right] \right\} / [1 - \exp(-1)]$$

where n is some positive index. Experimental results indicated that certain products of the size reduction conformed to the Rosin-Rammler distribution

if that material is going to be used in some other process down the line, it doesn't matter, except you can achieve a fairly substantial savings in energy at this point. This (Figure 4) is the specific energy in kilowatt-hours per ton versus the characteristic particle size, x_0 , and interestingly enough the machines tend to fall along a curve. You get some types of shredders giving finer sizes up here; traditional hammermill type machines fall in here; and another type of grinder called the Rabco system falling down here. This kind of information can be correlated against grate spacing, so we get a relation between energy and grate spacing. I might point out, interestingly enough, that when MRI did a study a while back, they took the data from Ames, I believe, and plotted it on this curve and it fell on the curve, which was comforting.

Now let's get into a little bit of modeling that produces the size distribution curves. Basically, all the model says is that you select a certain fraction of the particles to be broken and that represents the selection function. The key is the product that you operate on. There are various sophistications of the model. The simplest is called π breakage, which says the material goes in, a certain fraction is going to be broken in each pass, i.e., in matrix terms, $S = \pi I$ and the equation describing the process is

$$p = \{ \pi B + (1 - \pi) I \} f$$

Here $S(y) = \pi$ for all sizes y ; that is, a proportion π of the particles independent of particle size is broken according to the breakage function $B(x, y)$. The parameter π completely describes the process if B is assumed to be known and is a useful measure of the breakage effected by the process.

The repeated breakage cycle model is also useful. This model depicted by

$$p = \left\{ \prod_{h=1}^N (BS_h + I - S_h) \right\} f$$

describes the situation where the feed and product size distributions do not cover the same sizes, and the size ranges differ considerably. In effect the breakage process is considered as a series of cycles of mild breakage. Here $h = 1, 2, \dots, N$ refers to the h^{th} cycle in which the probability of breakage is S_h .

Two forms of the breakage function were selected as being appropriate for refuse comminution. They are a modified form of Broadbent-Collcott.

$$B(x, x_0) = \left\{ 1 - \exp \left[- \left(\frac{x}{x_0} \right)^n \right] \right\} / [1 - \exp(-1)]$$

where n is some positive index. Experimental results indicated that certain products of the size reduction conformed to the Rosin-Rammler distribution

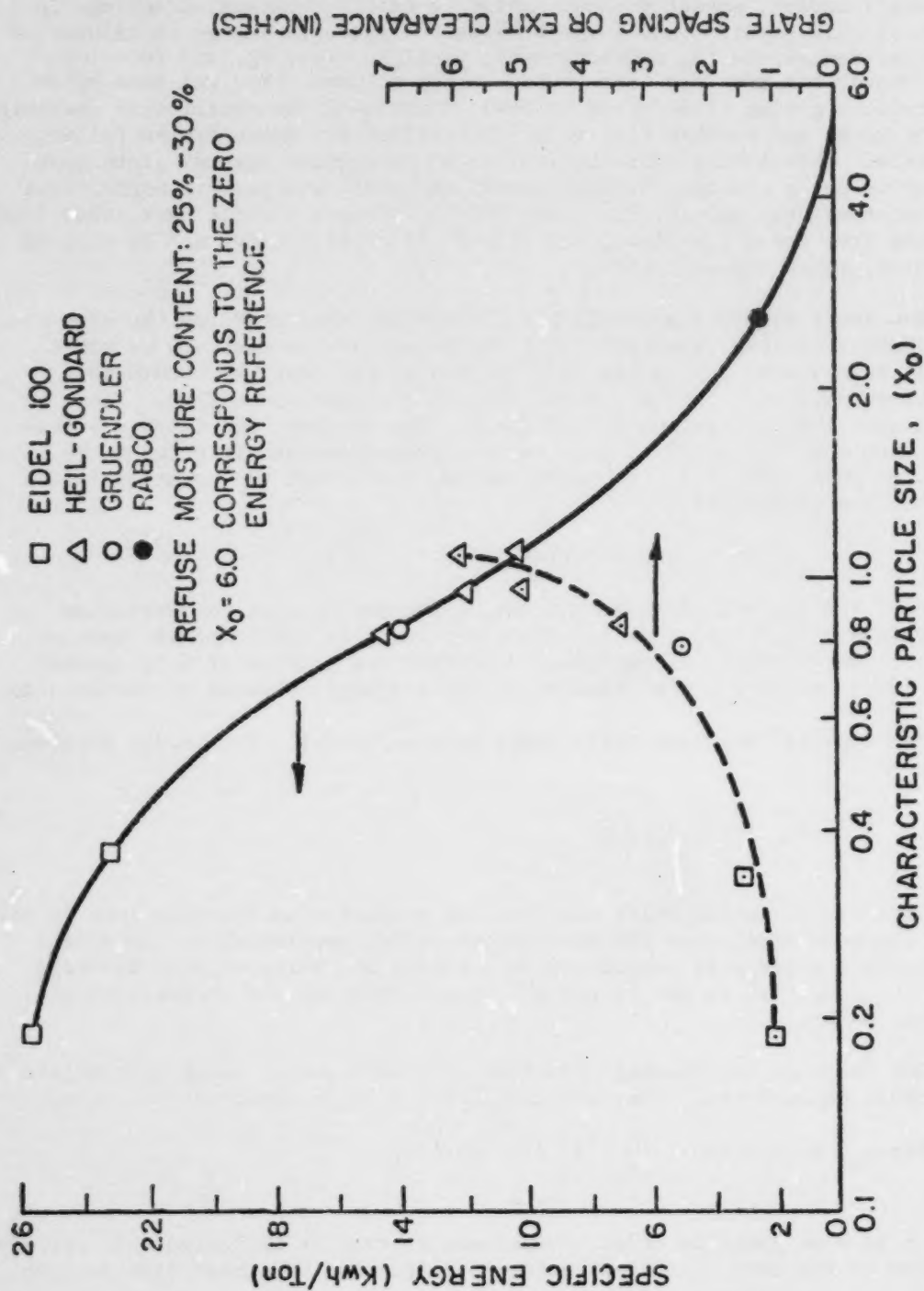


Figure 4

with an n index varying between 0.845 and unity. The other form was patterned after the Gaudin-Meloy distribution equation, i.e.,

$$B(x, \bar{x}_0) = (B(x/\bar{x}_0)) = 1 - (1 - x/\bar{x}_0)^T$$

The relation was necessary since the first relation for B did not simulate primary grinding.

We've done a lot of work trying to apply these models and let's summarize. Given a product size distribution, you can in fact using π breakage, predict fairly reasonably primary, secondary, and tertiary grinding (Figures 5 and 6). I will leave it at that and not try to go through all the curve fitting. In some cases we don't predict at all. Some models actually do not work at all (Figure 7). We've gone through a lot of studies of this nature, and deduced that we can, with some modeling, predict what's going to happen. We also monitored carefully the wear of the hammers. Basically the thing I want to point out to you is that when you start running the machine at lower speeds, you do, in fact, get a considerable decrease in the wear that's going to occur. I think that is a very important point which is overlooked. Along with this size reduction, we've done some work at looking at different kinds of screens and how they affect screening efficiency. We've looked at flat vibrating screens, rotary screens and we've looked at trommel screens. Here is a plot (Figure 8) of screening efficiency as a function of feed rate. For example, trommels tend to fall into this group, and flat bed screens tend to fall in this group.

We've also taken this ground material and looked at the size distribution of all the components of the materials and the incoming size distribution, sorted them all out, and measured the size distribution of all of the components in the waste stream (Figures 9 and 10). There's a number of ways you can look at it. Here essentially is a histogram (Figure 11) sort of plot versus different size spectrums. This was a breakdown of material that was in there to start out with--heavies and lights. We have also looked at the light fraction, and have broken it down into a size distribution (Figure 12).

What this is leading to is the work that we've gotten to now on finer secondary shredding. Experiments that we are now conducting relate to a fixed hammer machine, which is a high speed, fixed hammer machine with grates. Actually this is a light fraction put through that fixed hammermill and extruded in a California pellet mill (pelletizer). Here are some pellets which were produced from this fine secondary ground material. Our attention has been focused on examining how to arrange these systems. I would like to call your attention to the three basic kinds of things we have examined so far (Figure 13). One possibility is to say, suppose you just go and try to make a product finer and finer, down to one inch, and go to an air classifier, cyclone, screen and then a product. The other is to go through a primary shredder, air classifier, screen, and then fine grind and make a product. Another way of doing it is to put two shredders back to

Reproduced from
best available copy.

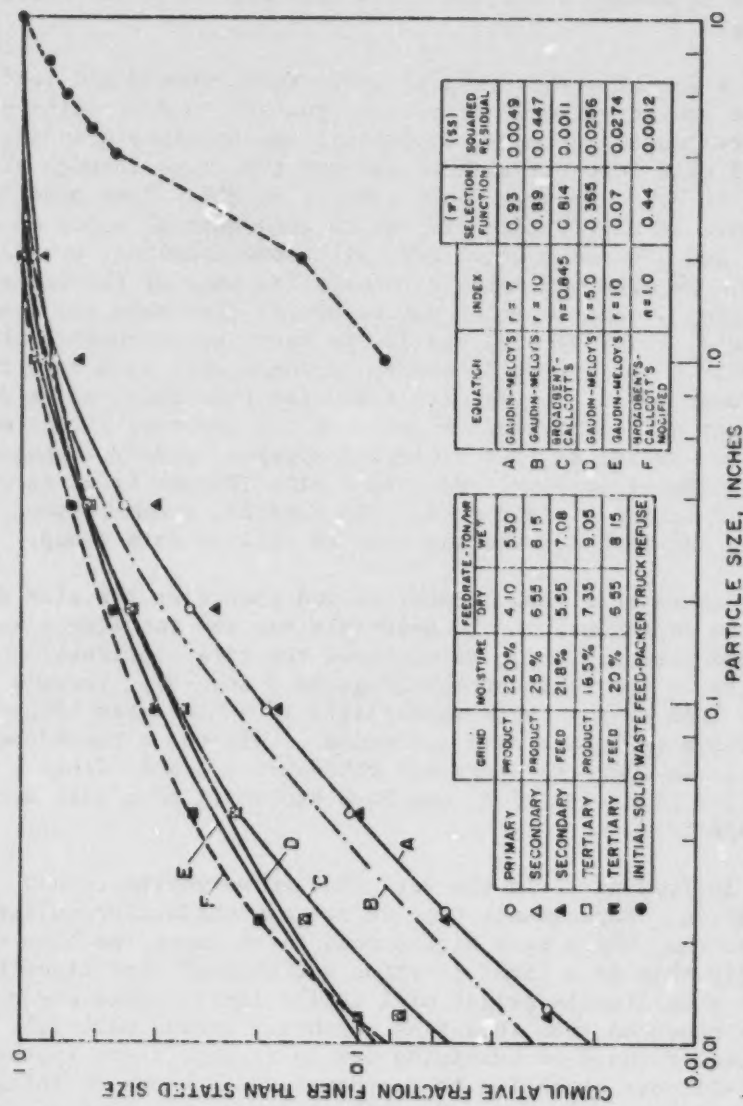


Figure 5. Comparison between computed and experimental product size distributions for primary, secondary, and tertiary grinding using the π -Brakage Process Model.

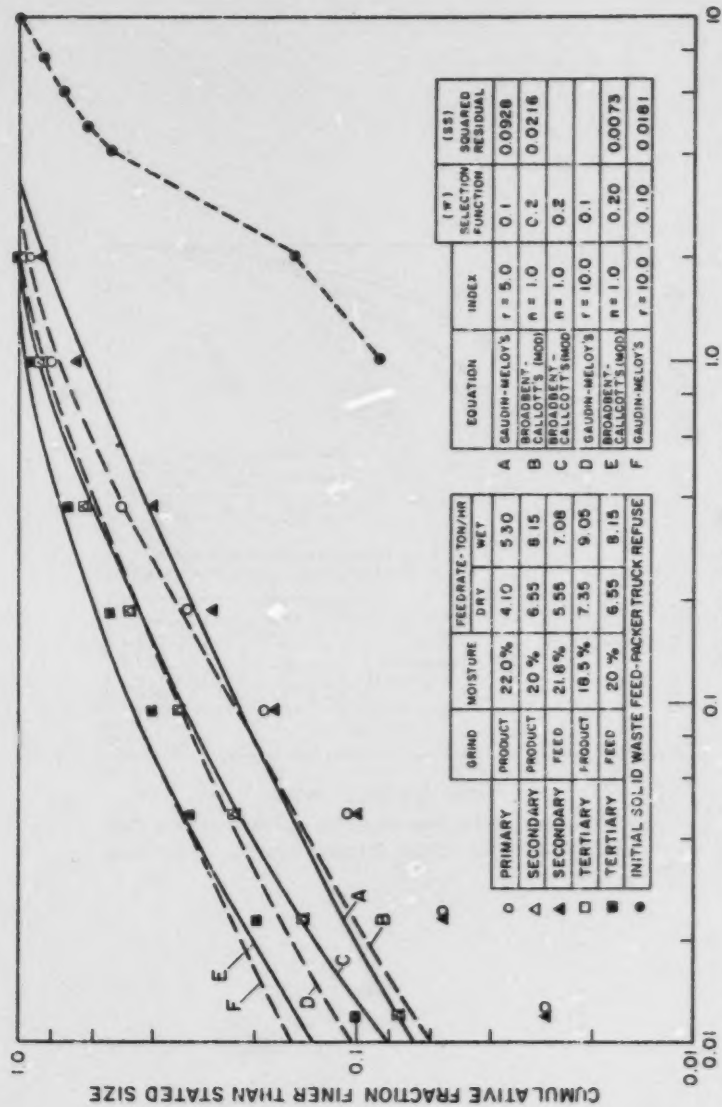


Figure 6 Comparison between computed and experimental product size distributions for primary grinding using the Repeated Breakage Cycle Model.

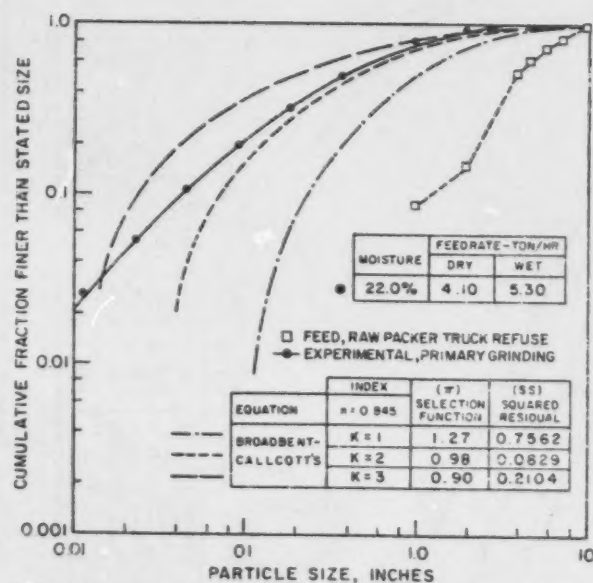


Figure 7 Comparison between computed and experimental product size distributions for primary grinding using the π - Δ Breakage Process Model.

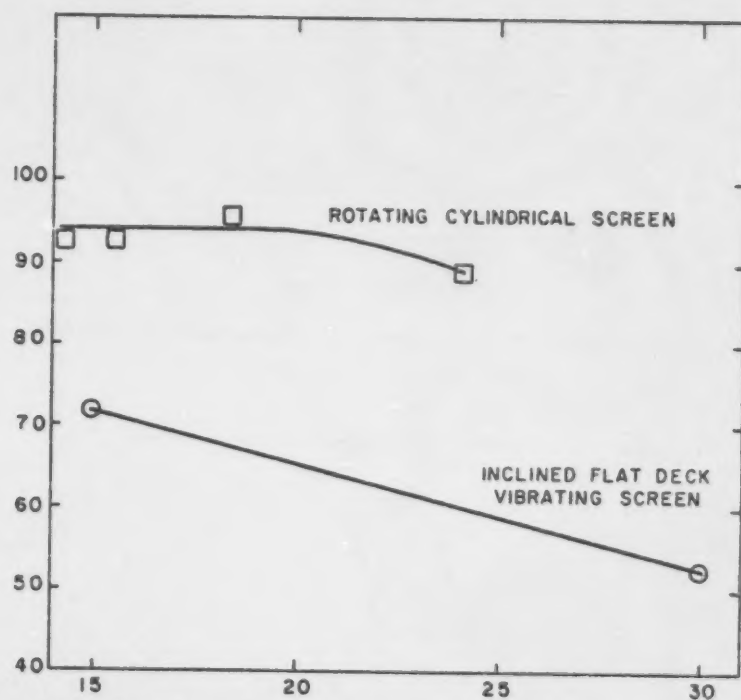


Figure 8 The effect of mass flow rate on the screening efficiency of the air classified light fraction.

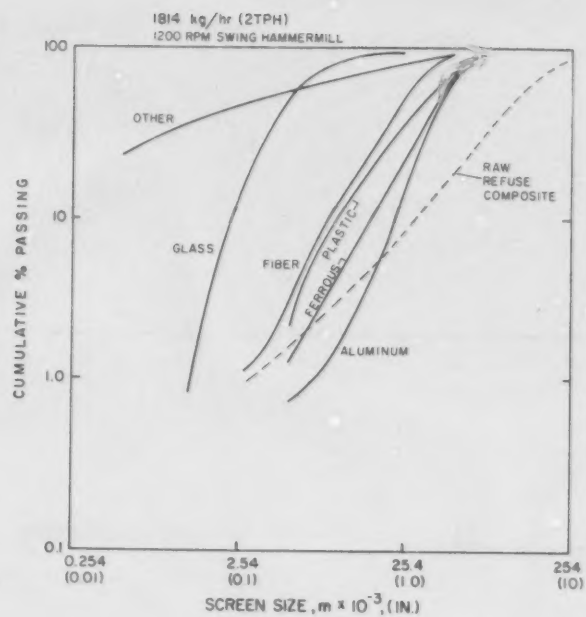


Fig.9 Component size distribution of shredded municipal solid waste.

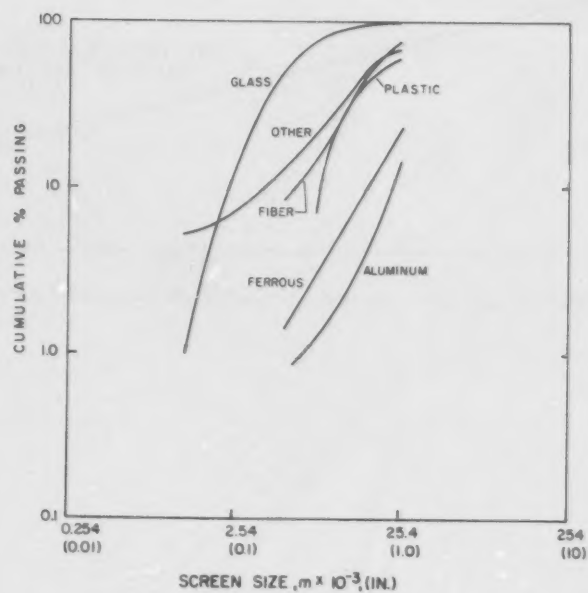


Fig10 Component size distribution of air classified heavy fraction.

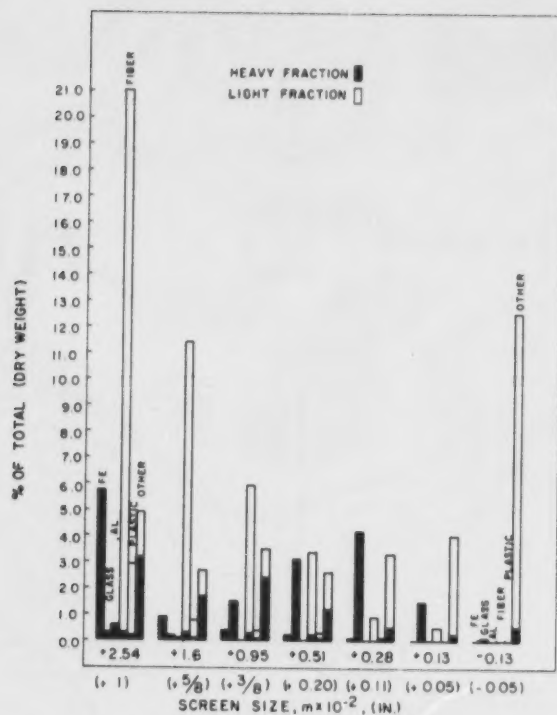


Fig.11 Composition of air classified shredded solid waste, 70/30, split.

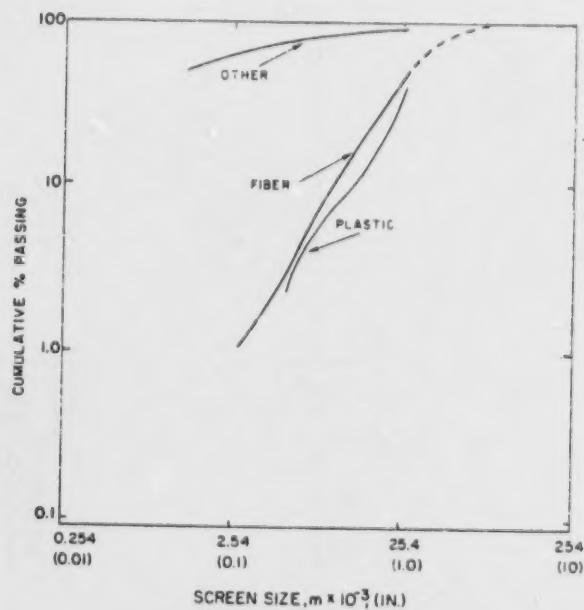


Fig.12 Component size distribution of air classified light fraction.

RDF PROCESSING SYSTEMS

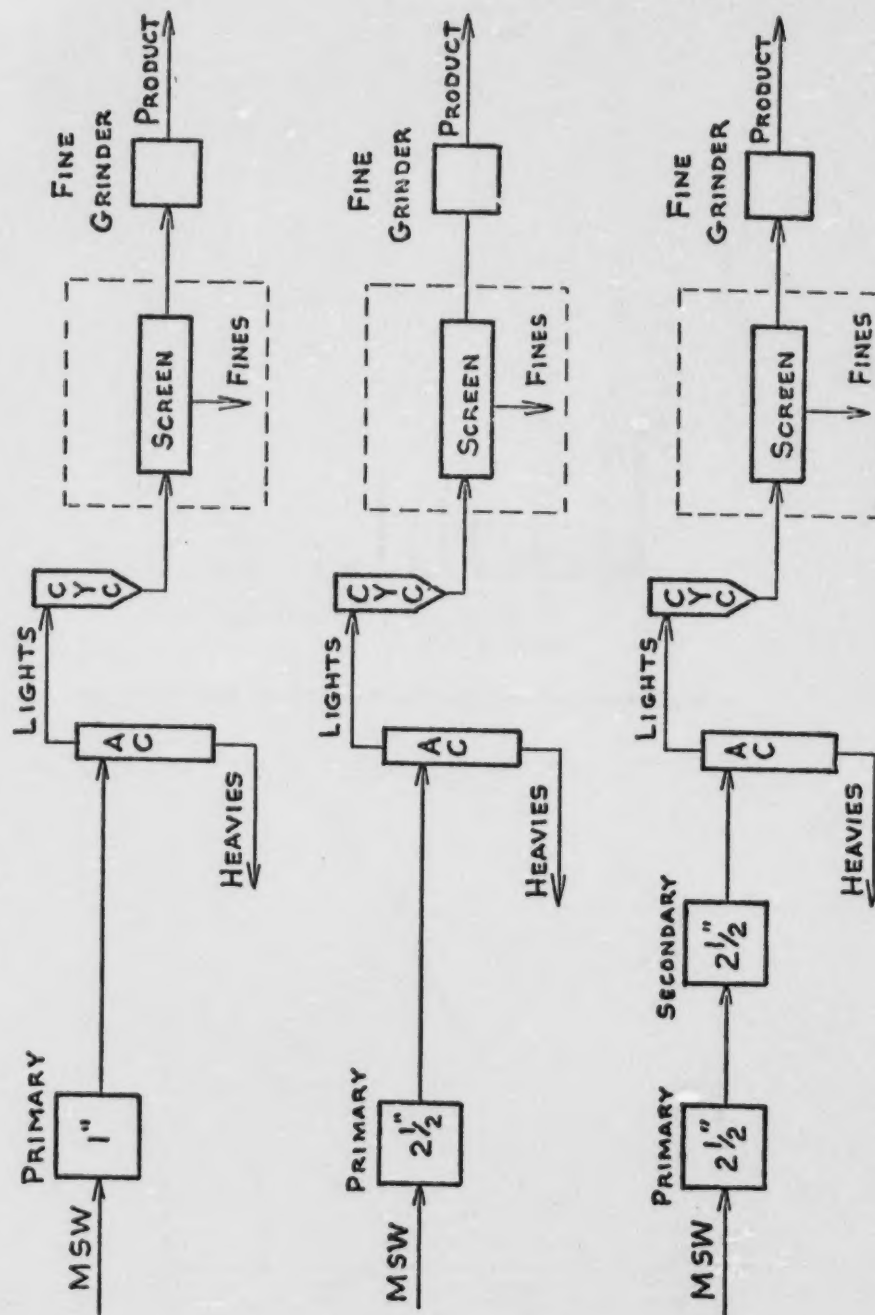


Figure 13

back which have the same grate spacing, and then going into product. So I'd like to show you what happens when you do that. The dash line around the screen indicates that we'd like to put the screen in and take the screen out and see what happens. In trying to figure out how to represent this kind of information, I drew these graphs (Figures 14, 15). We plot x_0 , that characteristic particle size, against the cumulative energy in kilowatt-hours per ton. This first one would be the solid line, then we have the dashed line and then the crosses. Here, for example, if we took a primary shredder with one inch grates, you would essentially move along this bottom solid line, and reach an x_0 of about 0.22 inches, the characteristic particle size, for a machine with one inch grates. This is now air classified, so then we'd move through the air classifier up to a larger x_0 because we've been dropping out material in the size distribution. Some energy is expended in going to a larger x_0 . We then go through the next stage of grinding. It depends now on what final x_0 we want to achieve. At this particular x_0 (0.4 inch) we would follow this path; likewise at this path a smaller x_0 (0.3 inch). You can start to get the feel for the relative amounts of energy which one has to expend to achieve various x_0 . The interesting thing about this is that when you connect up these end points, they don't fall into a straight line (Figure 16); in fact, what they do is tend to go up in a parabola, so as you get past Point 1 the energy that you need to prepare this material starts to really increase. What you are asking is, what minimum can I go to to achieve what I need without further expending energy. Here is a similar kind of chart if you do the screening (Figure 15). Essentially you come out with the same kind of thing. You follow along until you get to the point after primary shredding and work your way up the curves. The interesting thing about this is that even though you have to expend maybe 100 to 200 kilowatt-hours per ton to get this material, this is only about 5 to 10 percent of the energy content of the material that you're working with, so in that sense though it looks bad, it's not quite that bad. Now here's the correlation I want you to see--the correlation between x_0 and $x_{90\%}$ (Figure 17). The people I talked to in the industry like to think in terms of the size at which 90 percent passes, and I think that's a good way of doing it also, except that we find that the data and power consumption tend to correlate better with x_0 at 63.2 percent passing. It's not too bad down here at the small sizes but when you're here (the larger sizes), the data tends to be scattered. One of the things that came up here this morning was the idea of cleaning up the fuel, making it as bad as you can tolerate. It's interesting because when you look at this, it turns out that moisture content does not separate as material content separates, so by doing air classifying and screening you are in fact using the moisture content as a screen. And if you take a look at coming in screened or unscreened, there is a difference (Figures 18 and 19). When you relate this back to the energy that it takes to vaporize this material, then have a comparison of energy lost by trying to not screen the material. Another way of looking at it is, take a look at the heating values of unscreened material and screened material, then you can also look at the ash content between unscreened and screened--these are for pellets we may burn. You do get a significant change in the ash produced. Another way of looking at it is basically on the dry weight heating value, and you can get a feel for basically a change in the energy content of the stream and that's pretty much related to how much moisture is in the waste stream.

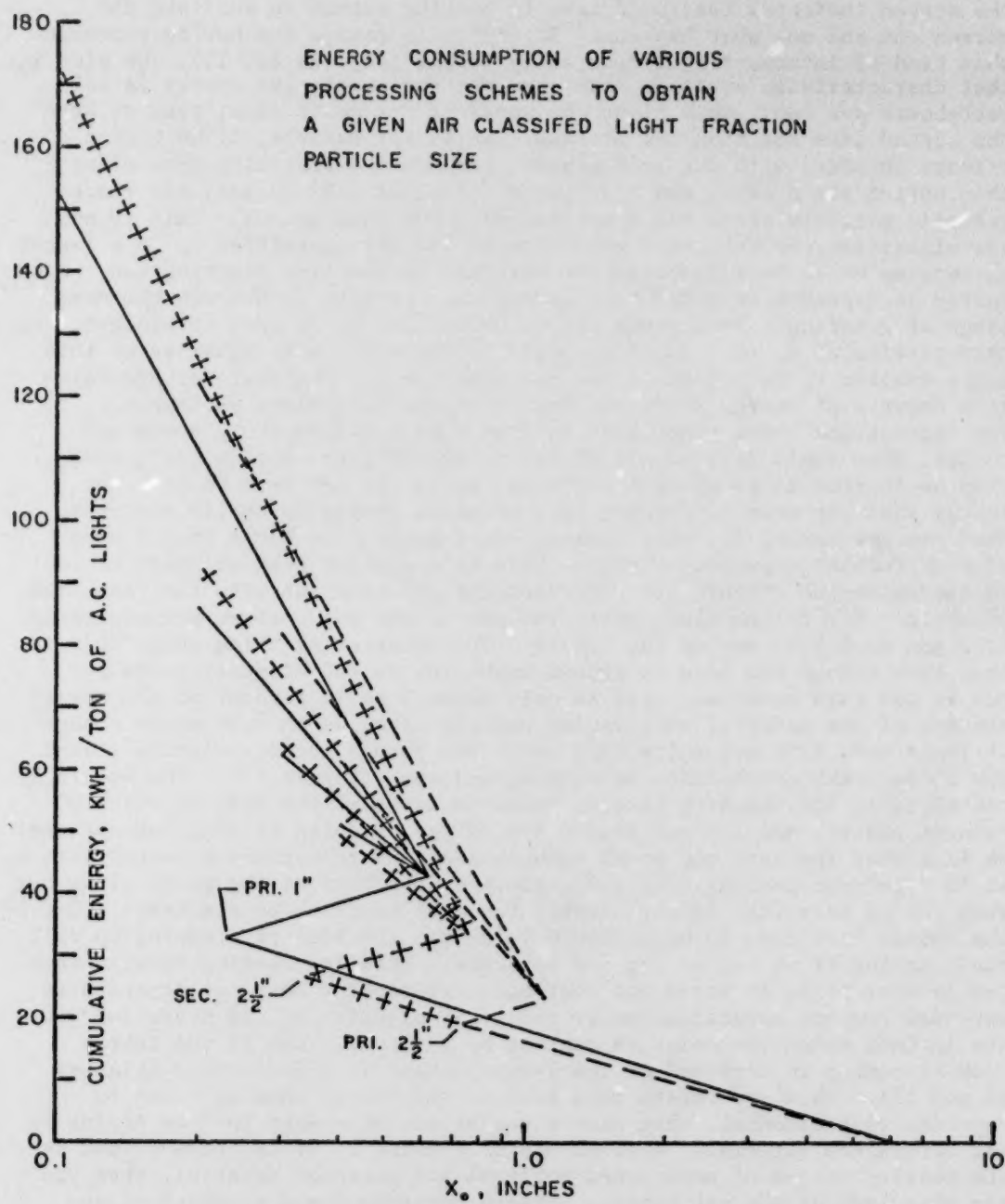


Figure 14

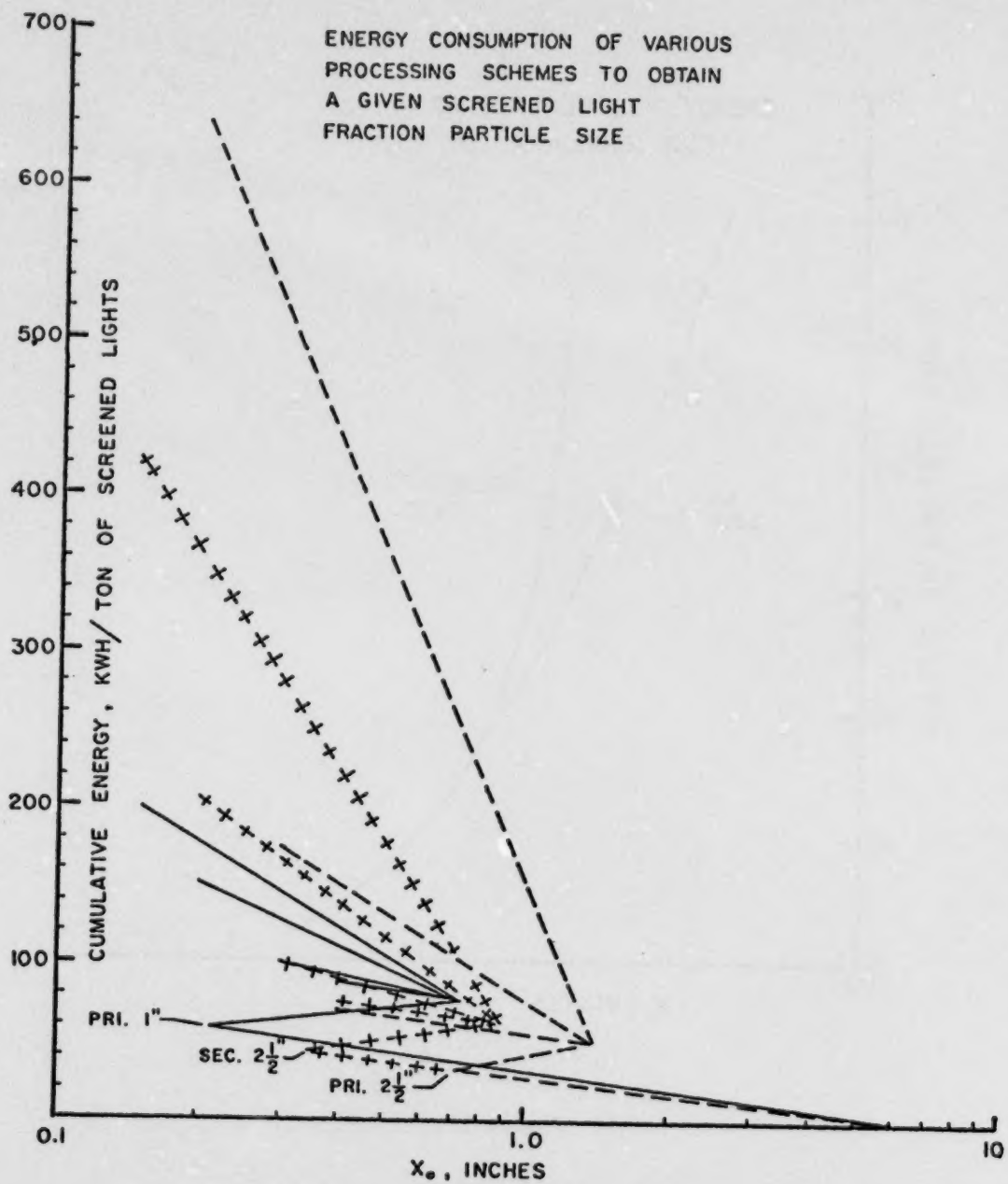


Figure 15

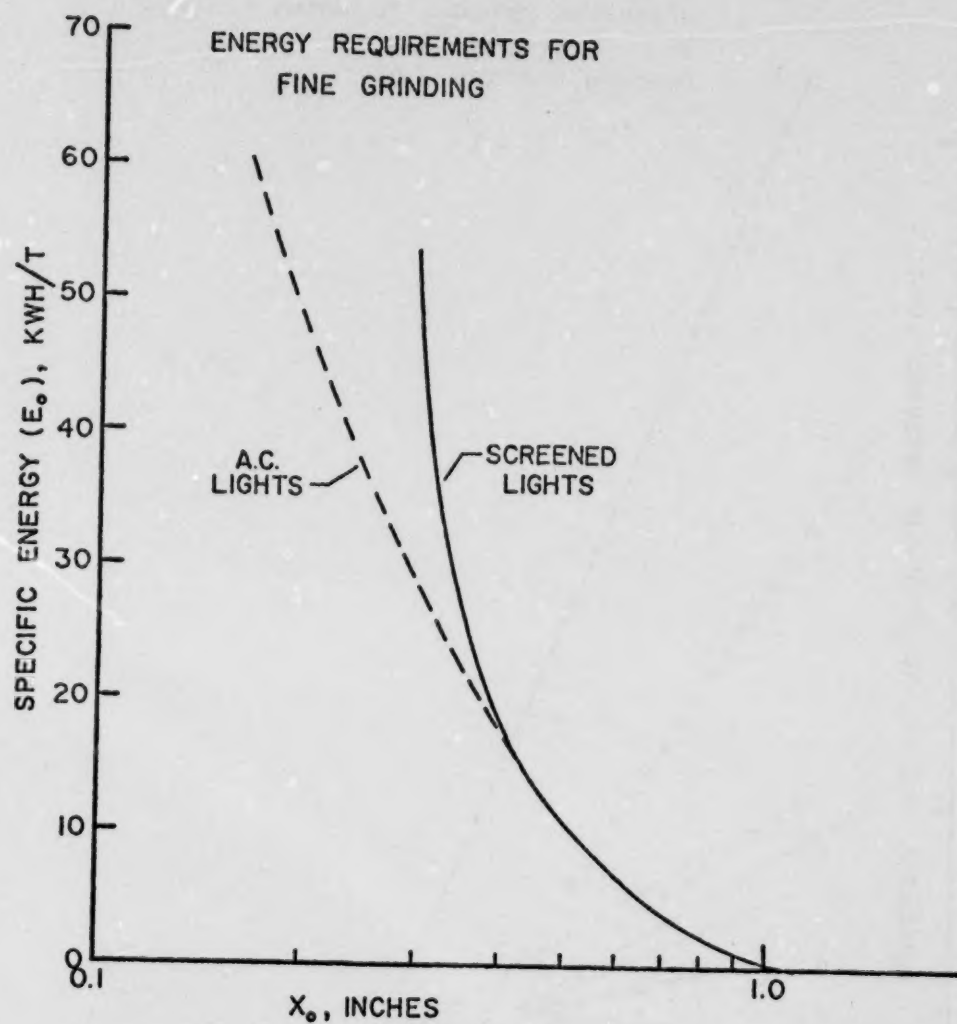


Figure 16

RELATIONSHIP OF
 X_{90} AND X_0

GRUENDLER HAMMERMILL

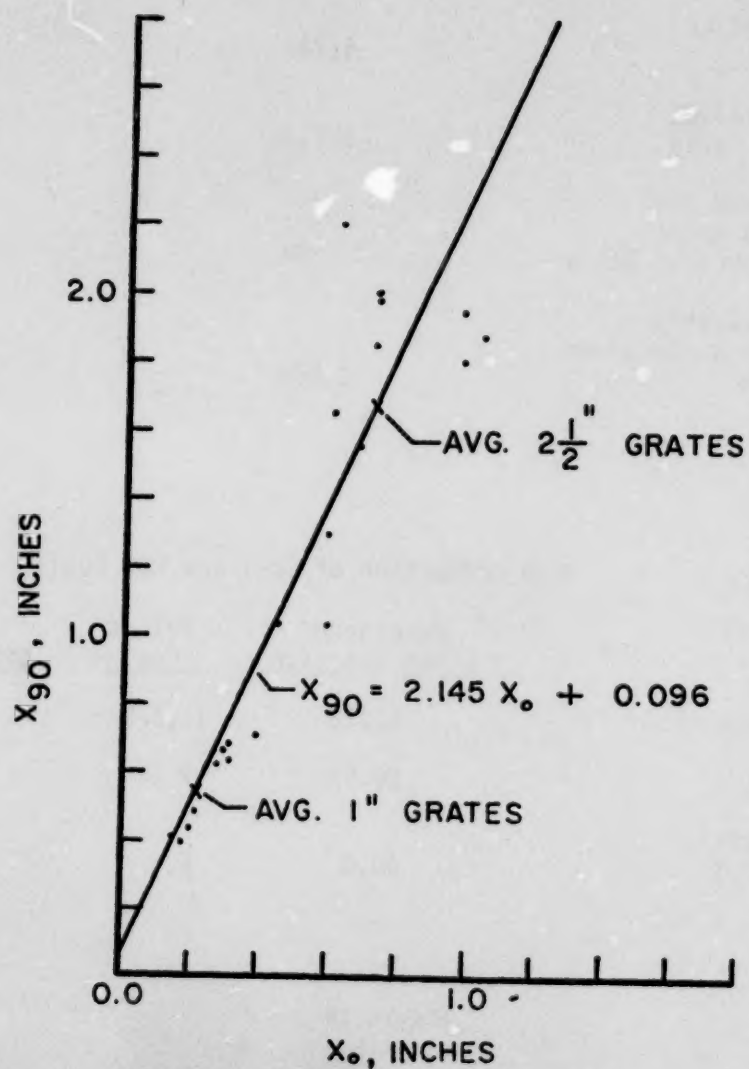


Figure 17

Comparison of Unscreened and Screened Fuels

	<u>Unscreened (BTU/lb)</u>	<u>Screened (BTU/lb)</u>
Heating Value, Dry Basis	6,733	8,000
Heating Value, As-Received Basis	5,218	6,696
Unrecovered Heat in Exhausted Water Vapor, As-Received Basis	254	184
Net Recoverable Energy on an As-Received Weight Basis	4,964	6,512

Ash Production of Coal and RDF Fuels

	<u>Unscreened Light Fraction</u>	<u>Orient Coal</u>	<u>Screened Light Fraction</u>
Heating Value (BTU/lb)	5,218	11,579	6,696
Ash Content	20.9%	7.6%	12.1%
Ash Production (lbs/MMBTU)	40.0	6.6	18.1

Figure 18

Decrease in Heating Value
Due to Presence of Moisture

Heating Value	<u>Unscreened Light Fraction</u>	<u>Screened Light Fraction</u>
BTU/lb dry solids	6,733	8,000
Moisture Content	22.5%	16.3%
BTU/lb, (as-received)	5,218	6,696
% decrease	22.5	16.3

Energy Loss Due to Unrecoverable
Heat Associated with Moisture Content
Vaporization of two Refuse-Derived Fuels

	<u>Unscreened Light Fraction</u>	<u>Screened Light Fraction</u>
Moisture Content	22.5%	16.3%
Water/Solids, weight basis	0.290	0.195
Energy loss, BTU/lb water	1,131	1,131
Energy lost in Exhausted Water Vapor, BTU/lb dry solid	328	221
Energy lost in Exhausted Water Vapor, As-Received Basis, BTU/lb	254	184

Figure 19

ALTER: People may wonder about the applicability of what George is talking about on shred size to the real world. We've looked at the particle size distributions of 10 shredders around the country. (One was originally designed for OBW, but we put packer truck refuse through at the time; another was designed for automobiles but we put packer truck refuse through it.) For these 10, we measured particle size distribution. (We had as few as seven data points for one shredder, but as many as 55 for another.) The statistical fit of the particle size distribution was very good to the Rosin-Rammler distribution function, as George said. We were able to compute the Rosin-Rammler parameters, which means now we have predictors for the PSD. There's a lot more to this, but one very significant point--there is a number, which George alluded to, called the Bond Work Index, which is the proportionality constant between the energy to shred and a function of particle size. This was developed for friable materials, and we were bold enough to test it for refuse. Within about plus or minus 20 percent we get the same number for the Bond Work Index for the refuse shredded in all 10 shredders. The number, by the way, for those who are interested is about 400, which is huge, it's tremendous, and we don't quite understand it. We've also measured the Bond Work Index using a small Heil-Tollemache machine with hammers; the importance of the hammers will be evident in a moment. We measured the Bond Work Index for some of the components in the refuse, and you do this by measuring energy input and particle size of the product and of the feed. We ran aluminum through a couple of times and looked at the primary shred, the secondary shred, and the tertiary--glass, steel and paper--and the highest value we got was for paper, which is about 200. All the other materials were lower. I don't understand why we got 200 and the refuse was 400. Thus, combining the particle size and the Bond Work Index, and if you can apply the theories for hard materials to refuse, you predict a relationship between power input and what George calls x_0 . We are starting to try to investigate this from the same point of view on secondary shred of light fraction, which is the material feeding our pelletizer. So far, (and here's where practicality may override all of the theories) the Heil-Tollemache doesn't shred textiles. They all went through and plugged the pellet mill. This shredder has since been changed (and maybe tomorrow I'll show you a picture of it) so that rather than hammers, the shredder has stators and rotors. It is more like a scissor and does a fine job of cutting the light fraction, including the textiles. Finally, regarding the information from Berkeley on the light fraction, its heat content, the effect of screening, etc., I'm delighted to see it. We have found the same things including reducing the ash below 12 percent, more like 9 percent. I think potentially it can be reduced even further. The effect of moisture in the fuel and the issue of drying we predicted in a paper (that has since appeared) where, for example, we computed the amount of RDF that would be necessary to dry the remainder. It is staggering. What the message really is, is you don't have to dry it. I'm glad we're in such good agreement.

TREZEK: I'd like to point out one other thing I forgot to say. When you look at those energy pathways, it would appear that what you want to do is have one machine and get down to where you want to go in one pass. Now that may be all well and good, except that we don't know what the wear

characteristics are going to be if you do that kind of procedure. Although from an energy expenditure point of view it looks very promising, from a wear point of view, what we need to correlate next is the wear versus this x_0 , and then we'll have kilowatt-hours versus wear. Then we'll really have the whole ball of wax completely put together. We're almost there but there's still other things we should look at.

HASSELRIIS: I wanted to make some comments on Dr. Trezek's presentation if it's appropriate now. Can you show that previous slide of kilowatts per particle size, could you backtrack on that? The major observation that I would make about these tests, is that they are all basically for a range of moisture content from, say, 15 percent up. Now when you start to shred materials with a lower moisture content, you run into an area where the material gets tough and very, very hard to pull apart, and then you turn over the hump, and you get to the other side of the world, where all of a sudden the material gets brittle and you are on the opposite side of it. But actually, I notice that in extrapolating this curve out to here is about where we find the kilowatts per ton is for brittle material. Somewhere over here not way out there, it's over here somewhere, like the 80 percent line is 200 mesh. In other words, you are talking here of using a shredder, hammermill, or any type device like that. I'm raising the question, the possibility, of jumping right through that machine, not going that way, and ending up with the total consumption for the whole plant in the vicinity of, say 40, 50, something like that, the whole operation, say, 30 or 40 kilowatts per ton. This we know from a lot of test data can be done, but it requires a process which gets into the other side of the hump. You get into that region--it gets very, very tough. There's another curve you have that's got the moisture content, and that also doesn't show what would happen if you went the other direction. It shows it going up here, but then when we go further back [unintelligible]. You shouldn't fail to know there's another part of the world you're working in, and that comes up under the subject of embrittlement, which it's necessary to accomplish particle embrittlement to do that.

TREZEK: You don't get that without an expenditure of energy, right?

HASSELRIIS: Yes, but in the vicinity of 30 kilowatt-hours per ton, is what you end up with. That's why I say it's really an extrapolation on the low end of your scale. What do we have here? 20 or 30? Extrapolate this, there's 15, 10, 5. That's not a bad extrapolation, as well as you can tell those points.

[Unintelligible question].

HASSELRIIS: Yes, you have to use a different operation. This curve doesn't show the particle size you are creating here; that's a variable that's missing, and it would have helped to explain this.

TREZEK: You have to go through this curve here. [Unintelligible].

HASSELRIIS: You have several points of moisture content here. You can correlate them as you go across here and you can extrapolate the relationship of the moisture content to the horsepower [unintelligible]. It does show a very strange characteristic, that's what I wanted to point out.

SPENCER: Was that the hammermill?

HASSELRIIS: No, it was a ball mill.

SPENCER: So it would really be a somewhat different phenomenon, perhaps, with the ball mill than with the hammermill?

HASSELRIIS: Yes. But there's preparation required (which in this case is a flail mill) is what I was basing that on as the first step, not a severe working like a hammermill or a secondary shredder.

SPENCER: Have you done tests with the hammermill or secondary shredder at low dryness to indicate what the kilowatt-hours per ton would be there?

HASSELRIIS: It happens that those machines are very unsatisfactory for really dry material or almost dry material. The dry paper just takes so much volume that the machine doesn't handle any of it. That's actually why you have to abandon that kind of machine if you try to go for dry material.

TREZEK: We tried ball milling light fraction [unintelligible]. You just couldn't get the volume in the machine that you needed. We tried ball milling light fraction coal, and we have gone through a whole set of different things, but you just can't get enough in there.

FISCUS: A look at the material loss through a hammermill. At St. Louis over a whole year of study totaling up the weight that went into the plant versus the weight that came out of the plant, you end up with a 6 percent material loss that's unexplained. We assume that this is moisture loss through the shredder. There are a couple of other people that experienced the same order of magnitude. At the plant at Madison, Wisconsin they found (this is not published but we talked with the people) that you could look for a moisture loss through a shredder of somewhere of around 2 to 5 percent. This is 2 to 5 percent of the total material weight. In the study conducted by the Bureau of Solid Waste, in a small shredder installation they reported something on the order of the magnitude of 4 to 7 percent. So I'm wondering, has anyone else looked at the material loss through a shredder?

DE CESARE: We've not looked at a shredder specifically, but through our pilot plant we get as much as 10 percent loss as best we can measure, which we've attributed to moisture loss from air classification and shredding.

HASSELRIIS: May I point out one obvious thing, and that is whatever horsepower you put into the mill goes directly into first, heating the material and then, drying it. Most of the time you try to correlate how much drying

you accomplish in the mill. The better part of it is created by the horsepower itself.

HOLLANDER: I took a photograph at St. Louis--of the shredder and the dust purge cyclone--which shows the moisture driven off right within the shredder. Under the right weather conditions, you can see a vapor plume coming off that cyclone right above the shredder. It's a very dramatic illustration of the phenomenon.

ALTER: This problem of how much is driven off, Doug, you are talking about averages. How do you measure if you shred and air classify? [Unintelligible] also been interested in how much moisture is "lost" in air classification; you think it would be pretty good drying step. Really, what it is, is that moisture is not evenly distributed in refuse. Sometimes, as you know, when you hammermill refuse you get a pool of water on the bottom, you free it, you liberate it. Yet if you took the raw refuse before it was shredded, then somehow homogenized it and there was a pool of water, it would go into the computation. I suggest that the simple statement of how much water is lost in shredding or air classification--the simple statement is meaningless. If you took paper, for argument's sake, or lawn waste, yard waste, some homogeneous matter, and said, all right now, I know the moisture content of this and then hammermilled, and then looked for the moisture balance, then I think that you'd see again a steam plume, but raw waste, I think it's meaningless. You are fighting the concept of averages.

FISCUS: We did measure the relative humidity of the air in the ADS exhaust, and also in the hammermill dust collection system, which was the steam plume that they were referring to, and also the particulate loss in those systems. The total material balance loss at St. Louis was 7-1/2 percent, and you lose about 1-1/2 percent, which you can account for to moisture gain in the air exhaust from the dust collection system to ADS, the particulate loss which you can measure there, and you are still left with about a 6 percent loss, which means that if you have a hundred tons coming in, you're only going to have 94 tons coming out. This has to be accounted for in the economic model of a plant.

LINGLE: I'd like to make a suggestion here. I think we are getting into very interesting discussion about some of the operating experiences of shredders, but what about the issue of what sorts of research or development or demonstration needs there are with respect to shredders? I think the reaction to the data presented by George Trezek was very positive, that these are the sorts of things we need to do. Should we continue this sort of research; if so how? Where should the Federal government be going in this area?

LAMB: I do think that other types of size reduction equipment ought to be explored. Everybody here speaks about shredders and now it's as if it's a fait accompli. It may well be, but obviously we have a slightly different point of view and have had some very outstanding success with ball mills.

Ball mills, at least conceptually, can present many advantages. I really wonder if the group is wise in closing the issue with shredders, because I really don't think that's the only kind of size reduction equipment that has been known to man, nor is it the one, to me, that is obviously the far superior of all the size reduction equipment. It may well be, but there isn't enough data to suggest that. We almost become self-fulfilling prophets by every time we put in a plant and put in size reduction equipment, they are shredders, and therefore they are the only equipment supplied. I wonder by what rationale that conclusion was reached. Certainly if you look at the power consumptions of shredders, you can see that if you try to correlate this to Bond or anybody else's theories on size reduction, if you look at the new surface area created, there is simply no justification for the power consumption. So when you are trying to spread fibrous materials, you don't follow the Bond equations for a less fibrous material, which is the point that you made. Is it worthwhile, for example, to try to make the materials more friable? Can you size reduce them better?

BENDERSKY: When we evaluated the shredder, we didn't confine ourselves to hammermills per se. We had classified all methods of size reduction under the generic name of shredders or size reduction. We, at least from our research vantage point, did not exclude other means or other methods of reducing the size.

LAMB: I still think it's well to keep the book open on that score.

RIGO: A major unknown is the power supply that you have to install in these plants for these shredders. We all know that current surges through the shredders are just incredible. They've got a locked rotor maximum, they've got idling power, but what do you have to install when you include the diversity of surge and load throughout the entire plant. This can be a very critical question. You're having to install a large new major substation. Point number two, as I mentioned earlier today, I'm afraid that if I put wood into my primary, by the time we get to the air classifier I will lose it all. If I'm dealing with a facility or location that has a lot of wood, such as in industrial waste, I'm afraid I might lose an awful lot of my heating value. Something that we are looking at doing now for a Navy pilot plant is presegregating the large wood, the pallets and boards, and running it through a pallet breaker, and then introducing essentially large tooth-picks into the secondary shredder thus bypassing the initial screening, size reduction, and air classification steps to eliminate this problem. There's a concept you might want to consider--handling pallets separately.

ALTER: Steve, you asked about whether this type of research should continue. I think absolutely. There's so little known, as I hope people will conclude listening to all of this discussion. I think there is so little known about size reduction of refuse it's pitiful. We could argue that maybe the friable theory shouldn't fit, but really it does. Why does it fit? I was joking to Dave Spencer, and expect this is true, that if we took the distribution of ages and weights in this room, we'd find a Rosin-Rammler

function it would fit. What we're doing really is describing what we already know, but we're describing it in a more concise manner. It's not the same as understanding it. I think that if we understood size reduction then, Tom, we could talk about all different kinds of devices, of size reducers, maybe of types not yet conceived. We do not yet have a basis for invention. Further, we haven't discussed at all and I'd like to just throw it in as a point not to be buried, the idea of a sizing circuit. We just talked about size reduction. There may be much merit in having a sizing circuit, so as to prepare homogeneous material for the next recovery step. Interestingly, this is done in some of the European pilot plants. If we want to air classify, for example, we just might be a lot better off having a homogeneously sized material, instead of a broad distribution. The sizing circuit is one approach to it.

TREZEK: One of the very first objectives of our work was to essentially find the grinder or the shredder for solid waste. That was one of the pie in the sky kind of things. It took us a while to try to understand what we were doing.

LAMB: Did you find the shredder? Don't keep it a secret.

TREZEK: I completely agree with your idea of not closing the books, because we have ideas of making the material self-destruct itself, you know.

LAMB: That was the only thought I wanted to bring out. It was not a criticism of anybody, it was simply an observation. If one were to sit in this room and listen, the only thing we heard talked was one, shredders, and two, hammermills. The two names generically imply the same kind of size reduction philosophy, and that is the high speed shaft with some kind of a massive device in it. I really question if the score card is all in, and that is really the way that all of us should be believing that this business should go.

TREZEK: First of all, it's clear that we probably shouldn't run these machines at as high a speed as they are being run. Secondly, I think we haven't even thought about all of the possible ways that you could, in fact, achieve this size reduction.

LINGLE: We'll entertain more questions, but something that hasn't been brought up is the issue of size reduction equipment in terms of scale. In other words, do we have suitable size reduction equipment now for small scale operations? Would anyone like to comment on that?

RIGO: Being intimately involved in trying to find something right now smaller than 20 tons a day, from what I have been able to find there isn't much out there that will take the abuse of the things that are in the waste. I think that we've got to spend a lot of time or at least some effort looking for small scale equipment that won't be destroyed when Fred is working on his Volkswagen and throws out an engine block.

ALTER: I disagree, Greg. I've seen pilot plants at 5 tons per hour using a flail mill that just seemed fine. Roger has one. What it is, is that at 5 tons an hour you have a chance to tip on the floor and spread out the refuse with a front end loader and pick out the engine block. There's a 5 ton an hour pilot plant in Sweden using a flail mill through a sizing circuit--a trommel sizing circuit--it's beautiful. They also tip on the floor and load carefully. Now I think in your case, when you start talking about a small plant, 20 ton a day maybe, for the Navy with all the dunnage and other material, perhaps it's a different ball game, or maybe it's a different sorting basis. You've already said you are going to sort and go through a pallet breaker, maybe. I worry more about the 200 ton a day, where Arnold, for example, winds up with a 50 ton per hour system and can take everything. You're too big, perhaps, to do a good job of sorting on the floor, but you're too small to take the chance that the VW chassis and engine block together will go through the equipment.

RIGO: The position that I have been forced to take because of what I have seen happen to some equipment, especially handling military waste, is even with a picker, even with spreading material, something's going to get through, and when that happens I don't care if it rips out the hammers, I am very concerned if it warps the rotor. At that point I'm not talking a matter of repair and replacement that is local, I'm talking a major renovation. The flail mill opening device is obvious, it will pass these hazardous things. If the plant is designed properly to take that, that's also great. You can accomplish basically the same thing with a trommel pre-breaker, where you open the stuff up and you get a change to spot objectionables. I think that we can protect things quite a bit if we start following the mining industry's lead, and put magnetometers in front of the shredder and just stop the feed conveyor when something massive gets in there. I think that's another safety factor. My concern is not reducing the frequency of interesting objectionables, but when it does occur, I want minimum damage.

LINGLE: There seems to be a lot of interest in going ahead on this, but we are going to run out of time on the other things. Maybe we should cut this off and move on to separation. We'll take two more comments and then we are going to go on.

WARE: The first thing I don't think we have covered, and it may not be that important, but it is to me, is why shred in the first place? We have two objectives in San Diego. Our secondary shredders are sizing to meet the requirements of our pyrolysis unit. That's a process requirement and we can't do much about it. It is necessary for conveying the material around the plant, for storing and reclaiming, getting rid of oversized particles, and for the efficiency of our air classifier. That hasn't really been covered much in this discussion, as to why we shred in the first place. Another side benefit, which we are very happy about, is that the homogenizing of the material makes it very storable, insofar as it doesn't appear to give off obnoxious odors, it doesn't support combustion, it doesn't attract

rats and flies. That is why we shred, for convenience of storing, and convenience of handling. These detailed research activities that give us horsepower and particle size distribution may become interesting to us in a few years when we come into optimization, but right now, quite frankly, they don't mean anything to us as far as design goes. We got a shredder to beat the hell out of it, to homogenize it so we can store it and move it around, and that's frankly all we care about. The size of the machine is predicated on the surge loading. We have to put a certain amount of material through that plant in a day to meet our requirements, and it has to be able to handle the worst thing we can expect; engine blocks and the like. This detailed information only comes in years from now, in optimization, cutting down that 1,000 horsepower machine to maybe 500 or 200, and the way it affects our heating load later in the plant. That's the first comment I'd like to make. The second thing I'd like to comment on, as far as the EPA goes, is what does the Federal government want to be able to contribute to this? Well, I found travelling around the country looking at other shredders, there is a vast difference in performance for the same horsepower. Let's take horsepower as a base. Bob Power's machine does better than three times our productivity with the same horsepower. The kind of information we need is why. Whether it's a matter of grate size, RPM, hammer size, the nature of his feed, whether that's a significant difference. We are doing experiments on our own, we are changing the grate size of our machine, but I'd like to know why shredders do what they do. I don't think Dr. George's information tells us that yet. I don't think the manufacturers could begin to tell us. When they offer a machine to do a certain job, they expect it to, but in a lot of cases it doesn't. That's the type of research we need--relating energy consumption to particle size reduction and differences in the machine, the differences between the Eidal and the Heil and the American Pulverizer and the Gruendler. Visibly there isn't much difference between our American Pulverizer and Bob's Gruendler but the productivity is there, the factor of three. So that's the type of research we would like to see and it could certainly benefit us in later designs.

HOLLANDER: The idea of size reduction is really not all that new. If you go back to the early forties, and back to the thirties, many shredders were installed in waste reduction plants and incinerator plants. In fact, in Louisville in 1949 they had a shredder for oversize wood wastes and corrugated. Most of the early shredder installations were installed too small and underpowered. They couldn't take the impact loading--they would stall, and when a shredder is stalled and loaded with material, it's a lot of fun. If the Navy is going to put in an installation, they want productivity. To put in a Mickey Mouse shredder for the sake of saving a few dollars, one that cannot receive all of the material that is fed to it, is poor economy and a poor resort to expediency. You have to look back at what has happened in the past, and all the trials and tribulations that were experienced. This whole idea is not a new one, it has come up before. When the St. Louis plant was being built, these aspects were explored and a robust machine was installed in the hope and expectation that it would not become the bottle neck.

LINGLE: Why don't we move on to the next subject, which is separation. I think tomorrow there's a discussion on technical obstacles. I'm not personally sure exactly how that differs from this discussion, so maybe we can continue some of these comments during that session tomorrow. If you still have questions or comments, just write them down, and we can bring them up tomorrow. There's a lot of fertile ground in separation. We can talk about magnetic separation, air classifiers, screening. We can get into the trommel issue that was brought up this morning. Would anyone like to start off with any salient comments on the issue of separation of wastes, and some of the problems and research needs in that area?

ALTER: I think there is a problem common to all separators, which is--we don't know. Let's take the oldest and simplest--the magnetic separator. I don't know about anybody else; I have not found quantitative data or design guides, beyond general brochures, on magnetic separators. There's very little in the literature as to what you might expect if you put in a separator of a certain type, in a certain location, for a certain feedstock, and you install it in a given angle, belt speed, and so on and so forth. There are few data on what's the composition of the product and its cleanliness. There's no way of making a comparison between Manufacturer A and Manufacturer B.

DE CESARE: The research that is needed is in unit ops. If EPA wants to put in money, it would be well invested in a lot of low cost (relatively low cost considering some other EPA projects) as far as basic research and air classification, nonferrous metal separation, Harvey said magnetic separation, this kind of research should go on. We need basic research and there is absolutely none. No one knows what parameters we are working with.

LINGLE: The obvious question I would want to ask is: How would you suggest that such research be carried out? That's really for another session, so we won't get into that here. I got the impression from Harvey's comment that perhaps some of the data, for example in magnetic separation, can be obtained by simply collecting data on what's in the field because there are a lot of magnetic separation units out there. It seems what Harvey was saying is: It would be nice if we had good data on the performance of all of those units.

ALTER: That's part of it. I would like to make a point of how it might be obtained. There are a number--a few now--reports in the literature of going into a plant and "evaluating" it, which is measuring the output of the magnetic separator while the evaluators were there. I suggest that's the wrong way to do it. Rather it has to be done by first going in and measuring for a given configuration, and then playing with the machine a bit saying, well, it isn't working quite right, and changing, trying to (I won't say optimizing) but at least making it better or even making it worse provided you record how this is done. This can be done in existing plants, I believe, but must be done in some orderly experimental manner.

LINGLE: All right, I believe that's a point that was made earlier this morning, too, that if you are going to carry out measurements, you've got to be able to vary your parameters, and that's apparently a problem in collecting data in existing facilities. They are interested in throughput and you can't really play around with those systems very much. I suggest that you need research facilities to do this.

HASSELRIIS: I think one generalization that everybody would probably agree to is that the magnetic separator may take all of the magnetic material, that may be possible, but it takes an awful lot of other material with it. The real problem is not what that takes, but how to get the other material out of it after the magnetic has taken it. This requires another step of classification which musn't be overlooked. I've seen a simple practice of winnowing work very well. You drop it into a container with a good wind and it cleans it very well. We'd like to control that kind of performance and blow all of the other materials out of the metals systematically. That is something which people do neglect to install; that principle in the plant usually has to be corrected afterwards.

WALTER: I suppose anybody who has visited Ivry in Paris has watched their drum separator take a gross cut at magnetic materials, and put it on one conveyor and drop the ash off into the space, and then watch that second belt conveyor (magnetic belt conveyor), which very carefully then took the smaller stream and separated light ferrous from the heavy ferrous. They do a very nice job of separation, in fact it is fascinating to watch because you can see a spoon come up the conveyor and actually levitate, sit there 6 inches above the belt trying to decide whether it's going to go with the good stuff or the bad stuff. So it can be done and it can be very cheaply and really quite simply.

BERG: Warren Spring Laboratory is having the same experience. Maybe somebody who has visited it could give a little more to the conversation about their use of the drum separator.

ALTER: No, that's not a magnetic drum at Warren Spring; it's a ballistic drum.

BERG: It's a ballistic drum there. They do achieve basic separation, though, using that type of system at Warren Spring.

ALTER: Yes and no. I'm sorry that the Warren Spring people weren't able to come today or at least send the movie. If I knew they weren't coming I would have brought slides everyone could see--it's a delightful place. They use a large drum, about 3 or 4 feet in diameter, rotating very fast (I don't know the speed), and they drop material on it. The idea is to separate by bouncing light material from what they call dense material. Essentially it's a food waste separation from stones and rocks and small bits of nonferrous metal. The latter all go into the froth flow circuit for glass recovery, and the food waste falls off into a waste bin. They also have another type of ballistic separator where they just take material off

a high speed conveyor. They've sometimes augmented with a blast of air, and again, it's a low density, high density kind of separation. (Warren Spring, for those not familiar with it, is operated by the Department of Industry of the UK government. It's kind of our equivalent to the Bureau of Mines. Their function is in the investigation of resource recovery unit operations, not necessarily a system.)

LINGLE: My perception, as perhaps people have been suggesting, is that air classification at this point in time is to a large degree an art, and that we know relatively little about what we can expect to get out for different types of inputs. What sorts of specific problems are there there, what kind of a program can we carry out to try to clear some of those questions up?

LAMB: What is the function of moisture content? What are the scale-up plans that everybody seems to feel it's the [unintelligible] how many zigs and how many zags do you need? It seems to me that if you could define the variables (I think fundamentally they are particle size and moisture content), one would then be prepared to decide when he sets up his primary shredder, does he want to shred to 12 inches, does he want to shred to 6 inches, to 2 inches, and maybe he would want to shred to one of those particle sizes depending on what he was trying to accomplish in the next step. Was he trying to remove lights from heavies or heavies from lights, or fines. None of that information is available, and that is fundamental information like was presented here a little earlier. That's the kind of information that everybody would benefit from, and it doesn't really prejudice one person's position or another to make the data publicly available. When you start to put all these things together in systems, then you are making judgments for people that perhaps the government or not really any public party or anybody other than the people who want to install this system are prepared to let be made public. It's the same way with a primary shredder. How many, what size product will be wanted, and if you look at that graph say gee, do I want to go to 2-1/2 inch or 6 inch? What does that mean, what is the implication of it? Do you want to trommel before or after? Well, if you trommel before some things don't even go to the shredder. So maybe the shredder is half the size required if you didn't trommel. You've solved some feeding problems. What things have you given up? It really depends on what shape you want the glass in before you recover it. Do you want it in big pieces or little pieces? That depends on what people are interested in. This is fundamental data that it seems would benefit everybody in the business. Are they going to put in a secondary trommel? If you put in a secondary trommel, what's the performance of it? What is it as a function of the treatment that goes before it? You can set down a matrix of data I believe, which people would like to have and it doesn't have to get into proprietary equipment, and it doesn't have to get into proprietary processes, and it doesn't require the expenditure of 25 million dollars. It's actually beneficial.

LINGLE: What you are talking about is basically a series of controlled experiments and tests on different unit operations for a whole range of preprocessing equipment.

LAMB: You just have to talk to people who have historically developed and understood [unintelligible].

LINGLE: Right.

LAMB: I don't think we have to reinvent science, and Newton's law is still applied, by and large. We seem to be [unintelligible] to talk about it.

LINGLE: Right.

BENDERSKY: Tomorrow we are going to be going over some 40 specific recommended research areas that we have identified and amongst them are two as far as air classifiers. First of all, the optimum operating condition for existing air classifiers; in other words, how to run them most efficiently.

LAMB: What does that mean?

BENDERSKY: Well, it means what effect does air flow have? What effect does feed rate have? What effect do the various parameters that you can control have on air separation?

LAMB: To me it's not so important to design how to run it "most efficiently" because depending upon the person's needs, efficiency may be something very different. But if you present a range of data, a matrix of experiments without trying to decide what conclusion you want to come to, if you simply lay the data on the table, then let people take the data and use that data to optimize their own system because they have so many variables to play with there--changes in composition, changes in feed rate, changes in product specifications. What we need is a matrix of data to be able to allow us to forecast what we think a change might have cascading through the system.

BENDERSKY: Agreed. Amongst our recommendations is the need for special test facilities at which you can manipulate these conditions. However, what we are also finding is that the present operators of plants are having to manipulate their own equipment and determine efficiency of operation. Manufacturers really don't know how to operate their equipment most efficiently under actual plant conditions and the operators are having to find this out themselves. It would be helpful to the operators if they had some basic information as to optimal operational conditions. The manufacturer puts it in, installs it, he tunes to what he feels is satisfactory, and generally it's left up to the operator to really operate the thing properly after he's gone. Another area that we are recommending is that there be some comparative tests done between the various basic air classifiers under similar operating conditions, so you can determine which actually is most efficient.

LAMB: Which most meets your needs.

ALTER: I think we first have to sit down and agree what is to be measured. Let's say you want to recover all the aluminum cans. I can drop 100 per-

cent of the waste and so recover all of the aluminum cans. Then we find that there's a difference at the same split with different air classifiers. For example, say at a 70/30 split, there may be a "dirty" heavy fraction or a "clean" heavy fraction, dirty or clean according to the amount of paper and other organic material included. The point is, how are we to make such measurements and comparisons? The terms and methodologies should be consistent. This group should meet to draft such methods, and I suggest perhaps we can reconvene in some sort of ad hoc group to do so. We have some procedures in draft and would like to get the input of others. If these comparative measurements can be made on the same base, we can better communicate. I agree with Tom; what you measure depends on why you air classify.

SPENCER: I agree that it makes sense to do that, and you can do that. It takes a lot of time, and it's hard to get out of committees, but you can arrive at how you measure the performance of an air classifier. The thing that I am very concerned about is that it can be very expensive to do this properly at the proper scale. You cannot underestimate the amount of dollars associated with the testing of one air classifier, let alone the amount of dollars involved in comparing several different air classifiers. I agree with what Tom says: When you are all done you just have to make the data available and allow the designers to decide what's the best for their particular application given the data, whatever it is, that you gather out of that. You can make measurements of performance, and some do perform better than others. But it's really expensive and you're not talking about some small potatoes in terms of dollars here to test this thing. If you want to test five different commercially available air classifiers, you are well up into the millions of dollars for a testing program--several million. Considering the cost of a single system, it's low. Considering the amount of waste with 50 systems, it might result from wrong engineering decisions, the overall cost again to the public is very low for such a testing program. To do it halfheartedly--you just look at somebody's air classifier and another guy's air classifier and get a couple of data points and try to make a comparison--is just a waste of money and probably money better not spent. I think you either have to decide it's something that ought to be done, we'll gather the appropriate amount of researchers and do it properly, or just don't waste your time.

BENDERSKY: One of the sources of information that is already available, but unfortunately only to individual people and individual companies, is the experience they have to go through to tune their own equipment. That information is available, and what I would like to see is more of that kind of information published if possible.

SPENCER: This idea of tuning equipment I don't understand very well, because the typical air classifier: Somebody says, well, my user, Utility X, can take a dirty fuel product and therefore because we don't have any bottom ash problems, I'll take 80 percent as a light, even though it's got all kinds of junk in it. Buyer Number 2 says, I need the cleanest doggone fuel

product that came down the pike; I've got all kinds of problems with bottom ash, and I need a very clean product that's not going to create bottom ash problems for me. In any event, probably most air classifiers work pretty much the same if you just take a particle at a time and throw it into the air classifier, and you tune it for that particular particle. Where they start to operate very differently is when you have a broad spectrum of particles going into it, and you have all the interference problems, and the problems of keeping the material liberated and free. That's where some air classifiers start to perform one heck of a lot better than others.

CAMBOURELIS: What complicates this kind of thing even further is, we really don't start with the true requirement. In the true requirement--we're speaking generally here about a production of a fuel for some place, a utility in most cases--you really are confronted with an adversary situation. The community, the user, is really an adversary to the buyer in a sense, because the buyer wants the best possible fuel he can get, and the seller wants to make the cheapest, lousiest stuff he can make and get away with. We really have to address that question as well here, and we are ignoring that a little bit, I think.

BENDERSKY: This comes back to what we were talking about this morning and that is specifications. What you actually have to produce, what quality of product.

CAMBOURELIS: There is no RDF, single RDF, there's a whole slew of them, and they'll be different in any city. Each plant will have a different kind of RDF, depending on the efficiency of "dicker" with the utility if nothing else.

RIGO: I think that we are looking at two separate problems in the air classifier. Number 1 is attackable through basic research, and that is, how does an air classifier work? The problem comes when you start looking at multi-phase systems. You've got some fundamental laws, and you want to look at how to get the coefficients to apply these laws to give us a handle on what one can expect to do with an air classifier. You have the other problem, Number 2, and that is, what does a particular piece of equipment do as opposed to the generic thing called an air classifier? The generic air classifier's function is to split lights and heavies and to de-amalgamate or de-agglomerate anything that's become an agglomerate, so you can effect the separation. That's one problem. The other problem is to quantify what a specific unit will do, how well it separates, how well it de-agglomerates. I can see a Federal role, and I'm speaking as a consultant, in doing the first--the fundamentals, what we can expect this thing to do. I can't be really excited about spending Federal dollars developing essentially a sales data base for a specific piece of hardware. What concerns me is that if you develop performance curves, effectively, for a particular air classifier, you are opening yourself up whereby you must do it for every air classifier, or face suit. No, I think you are going to have to be very cautious about doing vendor type sales data support research.

BURCKLE: I would like to digress a moment back to this concept of tuning a piece of equipment, and the value of that kind of data. I would assume that in an engineering sense, when a person has selected a process and the pieces of equipment that comprise that process, there are certain benefits in operating that process to produce the best fuel he can because of the tradeoffs on the other end. Even if a customer is willing to accept dirty fuel, there are problems that arise in handling that dirty fuel in terms of Number 1, getting it to the boiler by pneumatic transportation; you've seen that in St. Louis. That's a very expensive proposition. Although he can accept it in his boiler, he has maintenance costs in the pneumatic transport area that must be traded off against operating the air classifier at a more optimum point. So when all is said and done, I don't think there's that wide a rangeability that's going to be available after the process is selected. I think you've restricted your point or restricted yourself when you select the process to a particular type of a product that you are going to make; I'm just talking about the fuel fraction. The problem being is that you are going to want to produce the best fuel that your process is going to allow you to produce at a reasonably economic rate. I think that when it boils down to a specific piece of equipment like the air classifier, you're not going to have that wide of rangeability; you're going to be looking for a tune point.

FAY: I am getting the impression that we are looking for more data so that we can optimize the design of the equipment. I'm concerned that we don't go in the direction that a lot of us utilities went, say 10 years ago, where we designed our boilers to burn a particular kind of fuel, which, after a few regulations came down the pike, is no longer available to us. I think that if we get more data it ought to be used to design whatever piece of equipment we are talking about such that we know how to modify it in the future or to design in adjustments, so you can change it as the waste stream changes. I don't know what the waste stream is going to look like in 1985, and I don't think anyone does, but if we try to fine tune these things for today, you're not going to have everybody in trouble 10 years from now. I think you've got to build in some flexibility with this data you want to get.

SPENCER: I'm not sure that it's a matter of so much of fine tuning as much as it is trying to get some kind of a handle on information that's just not available, that's necessary for design. If you have all of the data available you can say well, this air classifier performs in this way over this range of input; this one only works well on this very narrow range of input. Then somebody can make a decision and say well, do I want to pay more and buy flexibility or do I want to pay less and buy something for my specific need? The problem is that the information isn't even available so that you can consciously make that decision today, or in any knowledgeable fashion in any event. We try to apply principles in some sort of gut feeling and what seems to intuitively make sense, but the real hard information that would allow us to support that decision doesn't really exist.

RYDER: This sounds like a good area for R&D (I'm not an R&D man), but merely testing existing equipment is going to tell you only what existing equipment is capable of doing, not how to improve it.

HASSELRIIS: If you think of all the things we are trying to do in this device, then you would realize you can't have one device that does all these things we are trying to do--not one simple device. Actually there're a number of different steps that these classifiers have to accomplish and it in itself is a series of unit operations, if it becomes a successful device with more than one function in it, maybe five or six. Then it's the number of steps that are inside of it that will be determined how well it does each of them. Each of them might need separate tuning, so this is what the device maybe really requires. The question is, how much of a compromise on that can you really tolerate. You can always make these things to pick up everything, and you can make them drop everything, you can make them oscillate between those limits, but you can't get a fine distinction between different types of things without using the principle that makes the selection. So you have aerodynamics, you have trajectories, you have accelerations of particles, you have the problem of making heavies go over here and the lights go over here and not have to cross through each other. It's a very complicated device and I think we mostly tended to grossly oversimplify what we are trying to accomplish in it. That's why the fundamental research on the several unit operations that are inside the device are probably necessary for somebody either to build it in the first place, to control it when you are running it, and get the results we want. We probably have to consider these devices have to be tuned as they are operated to some extent. As the shift of materials takes place there's an adjustment that is actually an active adjustment, not fixed, but has to be tuned. I think we have to anticipate that it's really a more complex device.

LINGLE: Let me ask this question, then we'll move on to the next area. Again in terms of scale, is there an issue in terms of classification equipment for smaller scale applications and also in terms of types of wastes. We've been talking mostly about municipal waste, but if you're going to apply these to possibly other types of inputs, do we know anything at all about that?

HATHAWAY: We've had a lot of experience working with feasibility of recovering energy from waste at different military installations, principally Army and Navy. Our ballgame is in the area of 30 to 60 tons a day. If we are real lucky, it might be 100, sometimes in the more regional systems. We're definitely talking a scale that is very far below the principal orientation of this conference. Consequently we are very interested in anything that can be resolved regarding scaling factors, not just of individual pieces of equipment, but of systems. Keeping in mind that our ballgame would also be marginally economic, and therefore we have an additional consideration to the problem.

LINGLE: I think that in response to one of the points he made, the scope of this discussion should include all sizes. We shouldn't only be talking about large systems, so please comment on any size ranges.

RIGO: Let me support what Steve has said, but add an observation. One thing that makes our life a little bit easier is a "tinker toy" game--that's what lots of people have called pilot plants--and prototype developmental units tend to be sitting in the size range we want. Now the problem is, that these things have also been baling wired together, and as was observed by the gentlemen from Occidental, we really don't know why they work, and as a result, if we go to duplicate it, I really don't like the thought of moving all that baling wire, but I don't know that I have much choice. I think there is need to develop small systems, and I think Steve will confirm this. The entire processing approach to small systems has got to be radically different. We cannot be capital intensive, because you just can't pay for it. We have to do a lot of tradeoff on the efficiency of separation. We also have to recognize, at least when we are tangling with the military, we're dealing with small-scale spreader stoker users, or at least stoker users if they are going to have coal. We are dealing with people that have steam demands, base loaded steam demands. We are dealing with an entirely different set of problems that you deal with in the civilian sector. In the small-scale civilian sector a lot of what is going to come out of the Navy work and the rest of the DoD work may hopefully spill over. I don't think you can hold out a lot of hope for the DoD work making a significant contribution to the rest of the country's problems. It's going to be an indicator that their waste is different, because their industrial to family housing mix is radically different than what you deal with in a normal community, and this is going to change how those unit operations work.

LINGLE: I would like to suggest that we move on. The last area of pre-processing equipment that we have not yet discussed relates to the subject of process control. It can involve dust control systems, shredder explosion control, fire control. I think this is an area where we know we've experienced some problems at some of the early plants, shredder explosions are occurring, dust has been a problem in some systems. Would anyone like to make some comments on some of the problem areas here and the directions we should be going in trying to solve them?

HASSELRIIS: I think that many plants started out with open shredders and find that the shredders are very powerful fans and blow the dust all over the place. We found this out at our early plants of that sort, but we have a fan, an air classifier, associated with the mill. The result is that the air classifier associated with the mill was a vacuum cleaning device and then the material was handled by air classifying by an air system, a ducted air system, into the bin. The result is that we had a clean plant by having that type of system. In other words, it is basically totally enclosed. There are many drawbacks to that, and we ourselves got away from it and got back into belt conveyors and back into the dirt. However, right where the shredding takes place it is apparently necessary to remove enough air and pull it through the shredder in most cases so that there is an influx and not an exflux, and the dust doesn't go all over the building and create health hazards and explosion hazards and dust collecting on all of the beams so you'll have a flash fire if it ever falls down. Basically, it appears that having a fan system will take care of keeping it sanitary. Now the fan

system develops another problem which is that now you have a closed duct and you'll have a possibility of a different type of fire hazard. Now the question comes, how do you handle that? Partly it can be handled by recirculation, which keeps the water vapor level high and reduces the chance of any dry materials being present in that system. I've observed in general that that type of recirculation of the moist environment is quite safe. However, the explosion hazard of somebody's can of gasoline is greatly increased because you've confined your system. What I'm saying is that the way to have a sanitary system or a clean system is to have it under suction with a bag filter at the end of the system somewhere, and then you've created a closed duct system which creates a need for an explosion proof or safe system. You can use a Fenwal type system to extinguish a fast pressure buildup, provided it is a ducted system. In other words, these ducted systems do lend themselves to a Fenwal safety approach, because they are closed and can be closed. I just bring this up as one of the directions that we may all find that we're heading in. We can't leave these plants open with all the processing exposed. We actually have to withdraw a large amount of air in order to pull the dust into the system and keep it out of the working spaces.

LINGLE: Is the dust control area one where basically we think we know enough to control it in terms of installing bag houses or whatever, or is it an area where we really do need to do some more R&D type work? Are the control techniques essentially at hand and just need to be applied, or is there still a lot of uncertainty about dust control or how to control dust?

LAMB: I think the equipment's available to be able to control the dust. I think it would be well to have a lot more information on the properties of the dust. For example, what is the safe range in which you can work with the dust, what's the lower explosive limit, what's the higher explosive limit? How do you want to design the duct system, do you want to specify that they be twice their maximum rate of pressurizing in the event there is an ignition. When you design a mill, do you want to design it to vent, do you want to design it to suppress? If you are going to suppress, well, let's suppress all materials. For example, gasoline, which requires oxygen, that's one thing, if you have dynamite or something which has a contained oxidant, that's another problem in terms of explosion suppression. It seems to me that another place that's noncontroversial and where people are prepared to share data, is in the area of safety. How should we fight fires? Should we use sprinklers, should we use hoses? Should the water contain wetting agents? Where do you sprinkle--inside equipment, outside equipment? Do you sprinkle the building? Do you design the building to be washed down? Or should you use vacuum systems?

LINGLE: You say that you think that information is available.

LAMB: I don't think that information is available. At least I don't think standards have been set for the industry which would say we consider these kinds of room Class 1, Group B, or we consider these kinds of rooms Class 2, Group 2, Division G, or something.

HATHAWAY: We have done some initial testing on properties of dust, and we are currently undergoing some chemical analysis of trace elements, toxicity. We found that the material is both highly fibrous and highly volatile. As a matter of fact, its volatilization rate is greater than the RDF coming out of the process. Its fibrosity presents interesting capturing problems. For example, if [unintelligible] adheres, you get a static field, and it's very difficult to get it off of conventional fabric-filled medium, short of knocking it with a baseball bat. Mechanical separators would be ideal, to capture the material that we don't know we can. Because of the volatility we would like to reinject it into the fuel production process. Again, these are ideas yet to be worked out in a pilot plant.

LINGLE: What about the area of the health implications of simply breathing the dust in plants? This is something that EPA has gotten into. The question is: How much research should we really do on the health problems associated with dust generated in solid waste processing plants? I don't know how familiar you are with some of the testing that's been done, but tests were run in St. Louis. Additional tests have recently been completed there. They found certain levels of bacteria and virus in there, but not necessarily levels which are higher than occur in other kinds of industrial processing plants or maybe sewage treatment plants and the like. Whatever absolute levels may be found, we still don't really know what the health implications are. That's the kind of work that could really go on for years and could eat up a lot of research dollars. Is this an area that you feel is important for additional work? Maybe MRI should comment since they are involved in some of this work now.

CHANTLAND: This general area, I believe from the public standpoint, is a highly sensitive area--extremely sensitive--so sensitive that I think it can mean the difference between your operating the facility or not operating the facility. The problem that I've seen in this whole area of research is nobody is willing to put up the money and go all the way. I think that without going all the way, it's a waste of money and it's only going to create problems in the minds of the public and are going to really get on your back. You've got to answer the question of what is the effect upon the human beings, the public, and the people in whatever area is exposed; what is the true effect? This is more than just gathering up how many viruses or bugs or bacteria or something you've got in the area, or what's its concentration and so forth. You know that human beings have certain abilities to ward off diseases, and these diseases are amongst us all the time. The type of things that we are getting into our plant are the same things that come from the housewife, the grocery store operator, and others in society--they put it there, and we end up with it. Supposedly the truly hazardous waste out of hospitals and others are supposed to end up in incinerations or destroyed by other means; they are not supposed to come to this plant. I think they are reasonably controlled. My only caution is that I think it's dynamite unless the real answers are given down to the point of its effect on human beings.

TREZEK: We had a research project which lasted a year at our lab, which we conducted with the School of Public Health, in which we had everybody instrumented and we measured what they were breathing and things like that. I think we've only actually begun to scratch the surface of this problem. As far as seeing things like hospital wastes, we've seen packer trucks roll in, and the first thing that comes out are a bunch of needles and blood bags and all this because the last stop was at a hospital. So I agree, I think we need more.

LAMB: You know the trouble is, those wastes are not pathogenic, and therefore they can legitimately deliver them to our facilities. We see them routinely--hypodermic needles, plasma bags. We don't receive any amputated limbs or anything like that, but short of that, we get everything.

LINGLE: Our perception at EPA has been that this is a very sensitive area. Since the initial tests were done at St. Louis and reported, we've gotten an awful lot of questions and comments on this area. I'd just like to know if there is pretty much a general feeling that this is a highly sensitive area to the public and may be very important to the future of any type of plant where shredding, for example, is employed and therefore is an important area for additional work by EPA in terms of research. Any yes or no comments?

HASSELRIIS: It seems that the big difficulty in this area is as soon as you start to investigate it, that creates the problem. If I ask you if you get sick from smoke, all of a sudden you'll start coughing, right? The suggestion brings it up. So it takes a very subtle investigation to find out whether people are subject to contagious diseases and so forth. You find your employees will suddenly realize that they have a cold and they are entitled to the full sick leave. So, it's extremely sensitive, it's got to be measured in a very careful way if we're talking about pathogens in the air. At the same time, we also have to measure a lot of background situations which have been going on all the time and nobody got sick. They were making out very well under these very bad circumstances, and make a comparison between the backgrounds. Those situations are also typical. As soon as you start to make the measurements, the people will suddenly be reporting all sorts of minor illnesses, and that's how they caught the cold. So that's why it's so delicate, I guess, that the measurement creates the disturbance, which now you can't turn off.

ALTER: We are dealing with people whom we are exposing to unknowns. At our pilot plant, to our knowledge, nobody has had a job-related illness, but we are still concerned that they don't get them. We have a program on-going with a small group of mostly professionals. I'd like to share this program with you and invite anybody to join in. We have also had contact with some of the overseas laboratories, and I think the only way we are going to advance the knowledge of worker health is to pool our data. I doubt there will be any plant with enough employees to do meaningful epidemiological

investigations. We are asking our employees to take an annual physical exam, at company expense. Also, they are instructed that if they have illness which they think is job-related, such as diarrhea, to go to their physician or the company physician. A form is filled out reporting the illness and its details. Names, of course, are kept confidential to guard the individual's rights, but the data can be used anonymously. If other people followed a similar protocol, we could pool health data at some future time, should it be necessary. There is also a new activity in ASTM Committee 38, the Resource Recovery Committee, within a subcommittee on health and safety in resource recovery plants. This subcommittee is working toward standards, definitions and standard methods of measurement, and will be acting as a clearing house.

BERG: I have more to say before the last few comments, which I appreciate for their candor and depth. Now maybe I can encourage MRI to comment on this some more. To put it in the most potentially negative light, we are talking about hundreds of communities around the country that may very well be doing large scale resource recovery within the city limits, near population concentrations. If the government gets involved in a situation or starts advocating a program that's going to subject people to problems that they haven't had before (not saying they are or that they will) but if that happens, you know I would feel very badly in retrospect. I would hope that we can all follow up this with some sort of data sharing at the very least effort. MRI is now doing work for us on that subject. ERDA is also doing some work on it at Ames, and as others have pointed out, there's other work going on. I at least would advocate very strongly that we talk about this a little bit more and see what we can do.

WALTER: I'm taking off my ERDA hat and putting on my Arnold Chantland, director of public works hat, and I'm saying to you, if you are going to look at these effects in a given processing plant, you had better be very prepared to extend them to the garbage collector. He right now thinks that he is exposed to a higher risk of illness because of his job than other people. So I'm just cautioning you, if you are going to do this don't stop, go to the trash truck. Better start looking at this, because he's going to be back down upon us.

HOLLANDER: What about back to the trash can? When I open or dump that trash can, what am I exposing myself to?

LINGLE: Did somebody once say you are what you throw away or something like that?

BENDERSKY: The City of New York did make a study of their garbage collectors' health, and some of their other public service people, and those results have been published. They are not very definitive. It does not generally show that a garbage collector is in a significantly greater respiratory disease category than other street service people.

WALTER: You're speaking of illness. Let me point that they are a higher risk for injuries.

BENDERSKY: Yes, yes, indeed. I'm talking of respiratory diseases.

CHANTLAND: I just want to say that a little information is extremely dangerous. As a recent example, some of the work that is being done on the examination of the emissions from our boiler systems. In the reporting data it was mentioned that among the many, many things that were being examined and so forth was mercury. At least one newspaper in this country reported already that we are finding substantial amounts of mercury as discharges from the emissions from the Ames solid waste plant. So that's what I mean by a little information is very dangerous, but I also appreciate very much what Harvey Alter is suggesting here, and we'd be most happy to cooperate.

LAMB: At the plant that we have we found that we were plagued with a lot of puncture injuries. Full steel-soled safety shoes are very effective against those punctures.

LINGLE: Thank you. Well, we've got about 15 minutes left, and maybe we can end the day with a big bang by talking about shredder explosions. Many of you are familiar with the Factory Mutual work that's been done on shredder explosions. I think they've learned a lot. I think a question which I have is, where do we go from here in terms of work on controlling shredder explosions or at least minimizing damage from explosions? Is the work that's been done sufficient, do you feel that you can design a system with at least reasonable control or protection or suppression of explosions, or is there a need to do significantly more work in this area?

ALTER: I think that it would do well to have a design manual of some sort on explosions, and I'm surprised that it hasn't come out already, considering that so much of this is known in the chemical process industry. High pressure reactors in buildings are designed with blow-out discs, venting, and so forth. Some shredders, as we know, have explosion doors, or other pressure relief devices. I would hope that there is some thought given to the response time versus a detonation. I'm also appalled that so many shredders don't have such explosion protection. I would advocate that somebody fund the proper design manual for shredders to avoid fire and explosions. I would include in there sprinkler systems as well.

BENDERSKY: I can tell you from having talked to a number of shredder manufacturers that they are not in a position to provide this kind of information.

POWERS: Who's had an explosion in their shredder? In the room?

WISELY: I would suspect that every shredder, almost every shredder in the country, has had an explosion of some kind or other.

POWERS: I'd like to know what the damage is.

WISELY: To the shredder itself?

POWERS: Damage to the building, to the shredder.

WISELY: Have you read the Factory Mutual work?

POWERS: It doesn't do much for me.

WISELY: Well, that's probably the most up-to-date information relative to at least recorded incidents.

RYDER: In Chicago, we have a 25 ton per hour bulk refuse shredder. This machine handles only bulky trash such as chairs, tables, refrigerators, bed springs, automobile tires, and so on. This machine is equipped with a Fenwal explosion suppression system and a sprinkler system to hold down the dust. So for the first 5 years, we never had an explosion. We attribute that purely to the sprinkler system holding down the dust as the Fenwal system was found to be inoperative. One day a portion of an acetylene tank partially filled with gas got in there, and they didn't catch it. It went through and blew up inside of the machine. In answer to your question, it blew out the relief vents in the roof and pushed out siding on the wall of the building. The relief vents, which were supposed to open if and when there was a pressure increase inside the building, were inoperative as over the years somebody went up there because they were leaking and fastened them down. There was not considerable damage to the building--nothing inside the shredder and only the conveyor at the bottom of the shredder required work.

WARE: We haven't operated very long, but we've had one explosion. I think the whole question here is a matter of magnitude, how you define an explosion, how big an explosion, or small an explosion. We fully expected them. We expect more, many more. What have we done about it? We've designed the feed hopper so it goes straight through the roof, with a membrane on the top, mostly to keep the rain out, and to maintain our vacuum system to some extent. Explosions we can handle. We expect them to blow straight through the roof. The last time it happened it did just exactly that. Detonations--I don't think we or anyone else can handle. Fenwal won't handle detonations. If it's big enough, neither will the wall of the shredder. So we isolate the whole installation, we have nobody within about a hundred feet of it, and we say that if it goes, it goes. If it's a mortar shell, it's going to blow the shredder to pieces. If we don't catch it in the initial separation, there's nothing we can do except make sure it doesn't hurt people. So we have not used Fenwal systems in our designs, and probably never will. The explosions we can let go harmlessly; the detonations we can't handle anyway.

LINGLE: Is it a matter of applying, in terms of the design manual, some of the knowledge that we have now about control of shredder explosions, or do we need to try to find some new techniques, second generation Fenwal, or whatever, to control explosions?

[Unintelligible].

LINGLE: So you are saying you don't think that's really a good opportunity?

SPENCER: You don't have a vertical hammermill, do you?

BENDERSKY: One of the findings of the FMRC report is that there are techniques available for fire and explosion developed for other industries that have not been applied in this industry. Where they have been applied, they have not been applied according to other standards. That would seem to be the first area that should be investigated and applied.

CHANTLAND: I've heard of some use of steam as a fire fighting device in the area. I wonder if anybody has any comments, or if there's anything happening in this area. I suggest that it is something to look at.

WARE: Steam is a well established snuffing device in the chemical industry. It's largely a matter of having it available in your plant. We simply don't have it anyway. Water in that respect works quite adequately if there is a fire. The generation of steam from the water more than adequately puts out the fire, not the water itself. I would not have thought it was a design criterion which you could incorporate unless you independently generated steam in the plant, and had it readily available in large quantities.

LINGLE: Thank you for those comments. I was going to end on the explosion issue but it was pointed out to me that one important subject has not been discussed, so maybe we can take 5 or 10 minutes and squeeze in a discussion of densification. Densification is something that is now gaining increased attention. The issue of industrial boilers as a market is one of the reasons for that. Does anyone have any particular comments on what we know and don't know about densification? What we should be doing? I know at least one person has some comments. Harvey, can you respond on this?

ALTER: Maybe tomorrow afternoon, if we have the time. I have some slides of the pilot plant and the densifier and I can make some comments.

LINGLE: Alright, we'll reserve that until tomorrow. At this point I should try to summarize, but that isn't going to be easy. Clearly the feeling is that in terms of unit processes, there's a huge data gap. There's a lot of data that needs to be collected, and we need to figure out a way to do it. This seems to apply to almost all types of equipment, but I must say that I was personally a little bit surprised at the first discussion that we had, which was on storage and handling, because I didn't get the feeling that there was a consensus that this was a major problem area, and frankly, I thought otherwise. If there is a feeling that's a major problem area, then maybe tomorrow there should be more discussion of that. I certainly didn't get the impression that there was a need for a big Federal effort in the area of storing and handling waste. It seems more problematical than anything else.

BERG: Just one other thing, at least at points during the discussion today, it seemed that there were more comments that people wanted to make than there was time available. If people would like to add addenda to what they've said, or introduce additional comments when you get the draft transcript to go over, then please feel free to do that. If you want to write them up tonight, then those could be handed in before you leave. Thank you.

SESSION 3: TECHNICAL OBSTACLES

Dr. Harvey Alter, Moderator

BURCKLE: The subject of this morning's first session is technical obstacles, which is another way of saying research needs, I think. The obstacles that we are interested in are those obstacles or barriers to the successful implementation of the resource recovery systems, as seen from the perspectives of the public sector, from the A&E's viewpoint, from the consultant's standpoint, in terms of helping us, the Federal government, to better understand how you perceive things and how to direct our resources in R&D to aid overcoming these barriers. As part of the study on preprocessing equipment, waste-to-energy systems, that Midwest is conducting for us, we have compiled a list of research needs based on their work. Now these research needs obviously (there are some 40 of them, quite a list) are based simply on looking at problems that exist, without assigning any priorities to them, without saying these are the problems that are important to the A&Es for such and such reasons, or these are the problems that are important to the people in the public sector, or the people in the utility business, so we don't have that flavor here. Now obviously we are going to come out of this with much more, hopefully, than information just for this particular study. This is just part, a very small part, of what we are trying to accomplish with the meeting. What we are trying to accomplish with the meeting, as we stated in the second letter that was sent to all the members, is a broad based understanding of these problems to enable us to better handle our overall R&D program. I'm hoping that this workshop will be the first of several in the preprocessing area. I hope that we will be able to continue these over the next few years. This depends a lot on how you, the members of the workshop, perceive the usefulness of this sort of thing. It also depends on how well we interpret what you have said and act on it in our R&D planning. So with that in mind, I would like to turn the meeting over to Dr. Alter, our session chairman for Session 3, and to the workshop members to discuss what you feel are the major technical obstacles to the introduction and use of resource recovery systems on a nation-wide basis. Thank you.

ALTER: Before we start I would like to add one or two things to what John said, giving some thought as to how this session might proceed. I view the

session as discussing how to proceed in the implementation of resource recovery in the face of technical uncertainty. I think that's what we really mean by obstacles. What do the implementers need to proceed. During the discussion I'll try to exercise the chair to make the distinction between what would be nice to have and what we may really need to have. It's always nice to have more and more information but we can't afford this either in time or money or people. I think this discussion might go in three parts. One, is what I call judgment and risk assessment, and we have to involve, as John said, the different actors here: the city who will be the customer, the A&E, and the systems designer. The second is the development of what I prefer to call the research agenda. We have MRI's research needs, and I think we should avoid the temptation to sit here and nit pick, whereas they have spent a lot of time and effort and careful thought into preparing this document. We might use it as our guide for discussion, or might not, but we should come up with some sort of research agenda. We can talk more about that when we get to it. The third part, which I think is essential, is who might do the research. We might talk about methods and format and inter-comparisons, and how we as a group might proceed, or how as individuals we might proceed, and keep the doors of communication open so that the initiative of this meeting is not lost. To return to my list, judgment and risk assessment, how to proceed in the face of technical uncertainty, what sorts of information do we need to proceed? I'd like to, if I may, have the discussion opened by first perhaps hearing from the municipal representatives present. What sorts of information would they like to have to diminish uncertainty? Inasmuch as there are no volunteers to start, how about Dick Bush. You've had some experience in this.

BUSH: We were concerned, for one thing, about the scale-up problems from the pilot or bench model up to a research and development program, and then from a research and development setup to a full working program. We all discussed this yesterday as one thing. Then there are other aspects that we are concerned with, such as the location of equipment as well as defining the operation of each individual piece of equipment, such as the magnetic separators. Should they go before or after an air classifier? That would change its function, for instance. We would like to compare, for instance, mini systems versus larger systems. We also touched yesterday on the variations of as-received material. We also touched upon quantities. Quantities that's generated in each municipality is really a problem, because when we tried to get a commitment from towns, as was brought up yesterday, even though they expect to give you say, 600 tons a day, they'll only commit to say, 400. So this is a real problem in determining how much they'll generate. Of course, I'm most interested in trommel operation, whether that should go before or after a shredder. These are some of the things that we are concerned with.

ALTER: Are there other comments from the cities?

LALKA: I think the things that we are looking for are basically three things. Number 1, reliability. If one were to implement the plant, there-

fore you've made a commitment to that facility, and presumably you should take all the refuse that comes in there and not turn any trucks away. Now if a plant is inoperative, then you have a problem. You have to direct the flow to a landfill or somewhere else, and this presents a tremendous problem. We don't really have good numbers on reliability due to the fact that most of the plants are small-scale, and when you are talking a 1,000 ton per day plant, we really don't know anything about how frequently it would be down or what kind of contingencies must be applied. So that's one major concern. The second concern would be the environmental acceptability of a system. We have very little good air emissions data on most of these energy recovery systems. Some Federal tests have been done on these facilities, but as far as Los Angeles County goes, the Federal testing methodology does not follow the procedures used by our air pollution people; therefore, they find it very difficult to interpret the data. Now manufacturers have made tremendous claims. I've heard things said like, there are no emissions from a plant, which is completely absurd. Somewhere in between there must be some level which we can monitor the system on an even basis, so at least Los Angeles County will have faith that what's happening in Baltimore, for example, could perhaps be investigated with regard to our air pollution codes. At this time we just have no faith in the numbers that have been presented. As I said, there are just so many different people making different claims we just don't know where to look. The third concern that we would have would be the economics. We have not touched on economics at this particular meeting here. Again, manufacturers are making all kinds of claims. We've seen numbers all over the place from 2 cents a ton to 20 dollars a ton. Different consultants look at the same process, and come up with different numbers. We really don't know what it costs to run an air classifier or any of the individual components of the system. We are pretty much at the mercy of the manufacturers. They come in and say an air classifier costs \$250,000, and we have to accept a figure like that. We don't feel too comfortable accepting what manufacturers tell us, because in the past we've had some bad experiences along those lines. So I think those would be our three major points of concern.

ALTER: Unless this group feels differently, I think economics is not an agenda item. Maybe it's a subject for a different day. You mentioned reliability, operating reliability, and certainly there is a paucity of operating data. How do we get it, how do we fill the gap in the interim? Is it possible to find out anything about reliability in the absence of many operating years experience in the plants?

RIGO: Even with many years of operating experience in the plants, unless the accounting systems were established and used to allow you to pull out costs and reliability information, you aren't going to get anything anyway. We found that out in taking apart Franklin. We just don't have a good handle on historical costs. I suspect that the Army study to assess the reliability of gas turbine generator sets from a 20-year historical record set down in the Kwajalein Islands for the Army is representative, and that was hopeless. The only way we could reduce the data was literally put it on microfiche, and that way we could say we reduced it by a factor of 20 to 1. So we are going to have to put some thought into how we want to maintain our records.

ALTER: Would it be useful to develop for general dissemination, uniform accounting systems in resource recovery plants? Do you think it is possible to develop a uniform accounting system?

BENDERSKY: We have looked into the present techniques that people are using in their accounting systems at these plants, and I can tell you that they vary all over the map. It is very difficult because of the variation in the existing accounting practices to make a comparative economic analysis. You really don't know how to compare, certainly not on an individual unit equipment basis. In other words, you can't ascertain from most of the existing records what it is costing them to actually operate any one particular piece of equipment within their line. People are assigned in the plant and they roam around from one piece of equipment to another, so you can't get manpower, you can't get basic information. One of our recommendations is that if comparative analysis is to be done, and indeed as it's pointed out here, if you are going to ascertain reliability versus costs, then there's going to have to be some standardization. It is going to have to be simple, something that's easily done in a plant, because you are going to upset normal accounting procedures, which is a difficult thing to accomplish. It's one of our recommendations that, if possible, some attempt be made at standardization of accounting systems.

ALTER: Let me tell you that the Center is developing an accounting manual for Recovery 1. If any of you are interested in having it when it's developed, and more important in reviewing it now, please let me know.

LINGLE: Harvey, you may be familiar, or may not be, we have developed an accounting guide for resource recovery systems, and I think it's at least a good first step toward what you are talking about, it may be that you are talking about something in a little bit more detail. I think the basic concept of being able to evaluate the cost of systems on an equipment basis, we do have a start in an accounting guide which we've developed. I think we'd probably be interested in expanding it, and making it more detailed.

ALTER: Other city representatives? Arnold, you had to proceed in the face of uncertainty.

CHANTLAND: I'm sorry that economics isn't a larger item on the agenda, because I would say that this is uppermost in the minds of the communities. Probably the smaller the community, the greater impact it has. I would like to relate to the operation of the equipment that we are talking about today. We're concerned about continuous operation, that's a part of economics. Anytime you are down, you are going to be losing revenue in all probability, and it's costing you a substantial amount of money just to sit there. When something does absolutely nothing, it's still being depreciated; those are real costs. In line with that, I would hope that everybody would be thinking of duplication. We weren't so fortunate to have duplicate lines, but

I certainly hope that others in the business will have duplicate lines, so that they can be working on one line while the other one continues to operate, even if you have to extend your operating schedule. Maintenance costs. There are certain wearing factors in almost every moving part, elements of almost any piece of equipment. A good look at these would be well to reduce the costs and economical impacts. Probably all of you are aware the shredder is the so-called self-destruct piece of equipment in this operation. It is certainly the larger in terms of maintenance cost and cost to operate. You literally wear this thing out from one end to the other; whether it's the breaker plates, the grate bars, the hammers themselves. All of these things are intended to be worn out at some period in time. The key, of course, is to get a longer life in this operation. I guess I'd have to say I'm a little surprised that the manufacturers don't have a longer track record. Hopefully there's becoming more of a record. We see some encouraging signs along this line. I hope that everyone will continue to explore new ideas or something that will reduce these costs.

ALTER: You raise an interesting point of duplication or replicate lines or redundant lines. Redundancy is expensive and ought to be, I think, calculated off against the alternative of diverting to landfill. Depending on costs of land, it might be cheaper to be down than redundant. Has anyone gone through this kind of tradeoff analysis and deciding whether or not in a site specific case, it pays or not? Mr. Ryder, did Chicago do this, or did you just put in duplicate lines?

RYDER: We put in duplicate lines to assure that we would meet our commitment to the utility. Our commitment is 3,500 tons a week and we can do that with one line. Of course should one line be down for two or three days we can shift over to the second line in order to meet our commitment.

ALTER: If the line were down and you didn't meet the commitment, is it really more expensive than having installed and operated a duplicate line? I'm really asking, was that kind of analysis done?

RYDER: No. We felt that there wouldn't be much need in building a plant that couldn't meet its commitment.

WISELY: We have done analyses similar to what you are talking about, Harvey, and the results will vary depending upon the local circumstances. There are some cases for relatively small facilities where there is no way you can justify a replication of the basic line. I think that one thing that many people forget is that there are a number of areas of required redundancy in any system like this, not the least of which is the place to which you are going to deliver whatever you are making. In many cases, this may be a more important element of redundancy than the actual processing facilities. For large facilities, I don't think there is too much of a question, if there is enough waste available to warrant it, that duplicate lines are quite desirable. The one thing that I think that always bugs me a little bit is, though, that people are continually talking about tons

per day; they should be talking about tons per week, at the very least. The rationale behind that, of course, is the daily input of waste in any normal municipal corporation is going to be something like 25 percent of the total weekly total, say on a peak day, and it may be as little as 10 percent of the weekly total on another day. It all depends on their procedure. Any facility of this type, I think, has got to take swings of at least that much.

ALTER: Has anyone else given thought to the probability of both lines being down, and the subsequent contingency plan. In other words, do you use storage space, or purchase enough trucks available to divert?

WISELY: There is no extant process for processing waste that cannot get by without some form of alternate disposal. I think it's going to be a long time before that condition can be reached.

ALTER: Are we leading now to a research need which is a probability analysis or to obtain the data in order to determine the probability, or reliability of a plant.

LEVY: A couple of points, one in response to what Ed said. I don't know what the current status is, but I know Franklin, Ohio, after it went on-line in April '74, up until at least recently, had never had to divert any waste. They had designed into the system enough, not necessarily redundancy, but other provisions to insure reliability. One that you mentioned was front end storage, the ability to store waste if you are down. Another one that hasn't been mentioned, which is the point I wanted to make, was one of intermediate storage, surge storage within a system. A lot of times a system goes down because of one individual piece of equipment. Maybe there is one piece of equipment prone to a lot of maintenance. In most RDF systems it's probably the shredder, but in a system like Franklin maybe it's some other piece of equipment more internal to the system. The way to overcome that was to put in surge storage within the system, so that you could be operating the front end, and you could be operating the back end, but somewhere inside the system you could be piling up, say, the crude pulp while you are working on the screen. You have 2 or 3 hours storage capacity and you can clean that out. You could be surge storing while you are doing repairs and go back on-line, and you've never really upset the overall throughput of the plant. So that's a factor, oversizing certain pieces of equipment relative to others that you know are going to be down more often than the others. Those things all go into an equation to determine how to design the system.

WISELY: This, I think, Steve, is perfectly true for a small facility such as Franklin, when you have a relatively few tons per hour that you are talking about. For any major facility, if you are talking in terms of say, anywhere from 70 to 80 to 100 or more tons per hour, then you'd pose a real problem in trying to put that intermediate storage into the facility. I don't think in most cases that you can be justified at all. I never even looked at that particular aspect, and I would doubt it very much.

SPENCER: In the Monroe County plant, we did reliability and availability analysis, and did a lot of the things that Steve was just talking about. In the tipping area we have storage for about one day's feed, which is 2,000 tons per day. We have about 2,000 tons storage in the tipping area. We looked at the probability of complete electrical outages and things like that, and determined that since we are right next to a substation, over the last five years there were only two outages, all of which were less than 3 hours over the past 5 years, and decided it wasn't worth spending a lot of money for. What we are worrying about weren't power outages, but we do have a capability of operating as a transfer station in the event that those lines are down, so that we have an auxiliary hookup to a compactor in the tipping area, which has operated on the order of 20 hours a day. It can move all of the material from the west side of the city out directly to a landfill through transfer trailers. We also have inside the plant, and spent a fair amount of money doing, putting in extra conveyors for bypasses directly from intermediate stages within the process out into bins and directly into trucks for transporting. Our transportation analysis allowed, then, for moving variable types of materials through given bins in order to keep material. Let's say in the event that the wet processing stage is down, for example, there's an intermediate bin that allows about 4 hours of storage intermediate to fix a particular problem. In the event that that exceeds the 4-hour period, we can then operate a bypass from there that directly removes the feed to that particular module out to landfill. Of course, with some of the products there are problems with respect to the materials handling in terms of densifying this product and so forth. We've added additional machinery and equipment in order to be sure that we can handle the volume as well as what we are talking about, in the event that we have to call for additional trucks, which we won't own at the time, or that we will be able to densify the material to the point that we will be able to move it at realistic costs. We also have redundant processing lines, and we did attempt to do reliability availability analysis. As you know, the availability of this string of equipment is the multiplication of the availabilities of the individual items. The biggest problem is that you haven't got the unit operation information that you need to do a proper analysis. If you want to know what the reliability of a transistor is, you go to a catalog and you look it up and you know that out of a thousand transistors that one is going to fail every so many years. If you look at the availability of shredders, the basic information doesn't exist and so it's not possible to do any kind of a rigorous analysis. As a result you are, therefore, left really to try to evaluate on the basis of judgment, engineering judgment. With what operating experience we do have, we try to assess what might happen. We looked at lead times of all the various spare parts for each individual unit operation, and what the repair times were, and went through rigorous analysis to determine what our inventory policies ought to be in terms of should we spare an extra rotor, should we spare an extra motor? In preparing our specifications, for example, since we had several shredders in the plant we did use single frame sizes for our motors so that a 1,000, 800 and 122 horsepower motor would all fit on the same frames. So if we spare one 1200 horsepower motor, in the event that we lose one of the other three, we can at least until we get a new one on-line, pull that out

of our inventory and put it directly into the plant. On the other hand, I think that while it's clear that it does cost money to inventory, it becomes more difficult when you look at individual manufacturers, in that the manufacturers have their own inventory control policies. Williams, for example, does not have any spare rotors available for any of their shredders or any spare motors or anything like that, and let's say lead time on a shredder rotor might be 8 months. Newell, on the other hand, will spare all of these things and will have them within 3 days. The exact analysis is really a function of the equipment manufacturers whom you are purchasing from, which even complicates it further. My own feeling is that it doesn't make sense to spend government research dollars on that particular analysis, because it's very system oriented, it's very manufacturer oriented. The general principles of how to do it are well known, but the basic unit operation information is missing, so that I think that it's really futile to try to generalize anything there. I think you just have to look at each situation, each design problem, and how much capital is available, and make judgment decisions based on that particular situation. In any event my recommendation would not be to spend design funds on availability analysis.

RYDER: Generally I would agree with that, but from a slightly different viewpoint. We have built-in redundancy because really, we have no choice. Those wonderful folks in the EPA are forcing us to shut down one of our incinerators, which has one of the best burnouts in the city. Unfortunately it doesn't have any air pollution controls on it to speak of, other than water sprays, and therefore we are going to have to shut that plant down. That's 1,000 tons of refuse a day that's going to have to go somewhere. Now if we had a single line RDF plant, and that single line goes down, where do we go with that 1,000 tons a day? We've got to be able to dispose of it somehow and therefore we need that second line, as landfills within the City limits do not exist. Also there's a little more to that. There are two ends to this plant. At one end we are producing a fuel, which if the utility doesn't get, they don't really care much because they can just add coal to replace the fuel that is not available. However, at the front end of the plant, there is refuse which has to go somewhere. At this end of the plant we don't have a choice. An additional advantage of redundancy is that there is a possibility we may find that perhaps 10 percent is not the proper ratio of refuse to coal. Maybe it ought to be 12 or 13 or 15. Also, the market might get better. We might find another customer. I don't know how all those could be cranked into any kind of an equation with all of these unknowns.

ALTER: Let's turn now from this emphasis on the city's viewpoint on risk and uncertainty, to the A&Es. What sort of information are they looking for, feel they must have to make the judgments for their customers, the cities?

FUNK: What if you establish some guidelines? This is a subject we can talk about from one end to the other. Why don't you get specific?

ALTER: I don't know if I have to get very specific. You have a number of clients and potential clients. You have to advise them, swing them to one system or another, one means of processing or another. There is a desire to move out and advance the state of the art or to do it safely like everyone else. What sorts of information are lacking, other than an existing plant, to advance the state of the art?

FUNK: Some of the problems that are quite frustrating in our business is evaluating pieces of equipment that may or may not be made available to a municipality. Let's just pick air classification, for instance. When we were developing and working with the City of Ames in putting their processing together, we took bids on air classifiers. We got two bids. The one outfit was going to scale up from about a 10 or 15 ton per hour plant. It looked like a pretty good outfit, but it had never had any experience operating on a large scale. The other bidder had one that was going to go on-line, and we could evaluate that performance before we made our final commitment. So we really didn't have a lot of choice. There was one available. That was four years ago. I'm not sure but what the exact same condition doesn't exist today. The people that do have air classifiers, or something that will work in that function, most of them are proprietary systems, and most of them we've consulted and asked them if they would bid an air classifier in a system, and a lot of them were reluctant to do so, and understandably so. Raytheon is one of them. Boeing has an air classifier; Allis-Chalmers, I guess might market one, but they've never demonstrated one on a large scale. You can go right down the line, there's a MAC equipment offering the system now that they claim is the greatest thing since sliced bread, but they have never demonstrated it on a large scale, so we are still stuck with the same position. Triple/S (I'm waiting for Chicago to get going)--they are offering systems, but until they have demonstrated, sure you can write performance specs, but the fact remains that if that piece of equipment does not work, you've got a white elephant sitting there until you get that thing squared away and get it operating. So there's quite a few areas. That's just one of the frustrations that comes in, being able to get your hands on what technology is available other than going the proprietary route.

CAMBOURELIS: I think you are describing as far as Raytheon is concerned, an accident of time. We perceived early on the necessity for coarse shredding to minimize glass content. We couldn't find a good kind of an air classifier, and ended up having to select an appropriate technique, and this resulted in the rotary drum. Now you folks got started 2-1/2 years ago making a selection process, and at that time there really wasn't anything for us to give you. Being a conservative sort of organization that requires of itself the demonstrated design, there wasn't anything there at that time demonstrated full-scale, which may be available right now, which would be a different kind of situation. We in fact do have a full-scale rotary drum, and they are getting now full-scale results, so we are in a different situation. I think that's one of the things that the conference in general has to recognize, that these things have never happened before,

many of them. It's the first time around. You have to be a little patient. In particular ASTM activities, where specifications are required, but you can't develop them until you've done it, and until you've done it you can't do it.

ALTER: You both hint at something that I would like to hear from the A&Es and others on--the idea in this field of incomplete information and experience, going out on a performance spec, Number 1, and Number 2, being faced by a "buy-in," where a manufacturer bids low. He wants his first sale so he can get the experience. Especially for the A&E but also for everyone else, what's your reception to such offers? Do you think it is possible to write the performance spec in a way to accept the buy-in and thus move along the deal?

WISELY: I personally do not think so. I think that any rational specification, particularly for a municipal corporation, has to be a combination of good performance and hardware. I think that otherwise, in general, the kinds of responses you are going to get for a request for bids might well be impossible to evaluate, that is on a comparative basis. This doesn't necessarily mean that you have to confine your request for bids for one specific generic type of equipment. There's no reason why you can't have an alternate in there. Even at that, I think that you must make an attempt to define the hardware element of it along with the actual performance.

RYDER: The alternate to that, Ed, is a performance spec. Somebody's got to design it, either it's a manufacturer or an A&E. Is there any A&E in this room who can stand up and say, I'll design a classifier and have somebody build it and guarantee that it's going to work? I don't think there is. Therefore, who is going to be responsible for performance? It's got to be the manufacturer.

WISELY: I did not mean to imply that an A&E should put himself in the position of designing proprietary equipment. No, but you certainly can define things to a point that would permit you to get comparable bids. I don't think that based on performance alone, you can get any kind of bids that are going to be worth a damn, really.

HASSELRIIS: The advantage of a contractor taking total responsibility for a plant (that's just the way it works) has made it possible for us to accept whatever type of guarantee a manufacturer might offer, but not really have to depend on it too much. It made it possible for us to buy a piece of machinery, get it in the plant quickly, and find out what's wrong with it, and fix it ourselves, and simply not expect to have to see something proven beforehand. That's a risky procedure, and it's the only short cut to everybody standing around and waiting for somebody to produce something that's guaranteed and never have it happen. We have been able to put our plant through about four generations of improvement in 4 years simply by going ahead, failing sometimes, succeeding sometimes, but always managing to work and find out what the faults are. Even today, we received one of these--like a feed bin--and it works in principle. It wasn't designed for the

purpose, it is an available piece of equipment, and we find we have to rebuild it. We find that in certain places the welds are wrong, the shear pins that they were protected from major failure don't exist. There are many, many faults in it, and we end up rebuilding it. What does this say, is that you can't hold manufacturers or anybody else really responsible for a lot of things, but the simplest thing to do is to allow in your budget a major retrofit budget. In other words, whatever you do, figure that you are going to have to spend a substantial amount of money changing the equipment and improving the equipment, and you're going to build it on the job. Now you can appreciate that municipal bidding doesn't permit this very readily, but I have heard one municipal operator say that if he had 20 percent extra in the price of his total plant available for retrofit it would be about right. If he had had that money to spend himself, it would have been possible, but if he had to do nothing but blame the manufacturers and get them to do their job, it never worked. So that's a recommendation that people think along those lines to allow the money to go ahead and make these improvements on the equipment as they receive it, and it is one way out.

WARE: In our position we find ourselves constrained in two ways. We are a private developer. We are trying to come up with our own technology, new ideas, we stick our neck out. At the same time we are expending government money, which means we are required to go to the lowest bidder in most cases. In both circumstances we have found a full spectrum of response from manufacturers. When we write a spec as well as we can, and the equipment that we receive doesn't perform, we've found the full spectrum of responses, from the manufacturer being willing to do anything it takes to get his machine to work, to absolutely no interest. The responses haven't been a function of the size of the vendor, or the nature of their business; I think it is very much a personal thing. Some vendors are selling us pieces of equipment that they can't hope to make money on in the future in similar businesses. Others, like shredder manufacturers, one would think they had a lot more potential in their future markets for these machines. All I can say is that you have to investigate a vendor for his ability to make a machine, the availability of the parts, the performance of a similar piece of equipment in the past, and finally, and it's quite an important point, his responsiveness. His responsiveness you can generally only find from other users, but I think it's worthwhile when you are comparing bids, and when you are selecting a vendor, to have gone to a previous owner of similar equipment or somebody who has dealt with that vendor and find out what kind of response you have. Specifically, in the case of our shredder, I mentioned yesterday it isn't performing the way we expected it to, it's certainly performing worse than other similar machines, the vendor is most happy to supply \$10,000 worth of interchangeable parts to make it work better, and at no cost to us. This is in the performance guarantee. We have performance guarantees on every single piece of equipment we've ever bought, but enforcing them is a totally different world. I would again recommend that anybody here who plans to buy a piece of equipment should investigate previous owners of that vendor's material.

SPENCER: Pete, did you have performance bonds on all of your equipment as well?

WARE: We didn't have performance bonds, simply a specification requirement that we would retain a percentage of the purchase price.

SPENCER: Did you get away with this?

WARE: Only in a few cases where the delivery was such that we were still within the warranty period by the time the machine started up. We still had retained 10 or 15 percent.

ALTER: Was the warranty more than materials and workmanship?

WARE: No, it was variable with the machine, because a lot of cases the vendor came with a proposal that for some reason or other didn't incorporate or claimed exceptions. But in most cases they were related to performance. In other words, we gave them extreme characteristics and required a certain product out the end of the machine, and have required them to stand by that.

SPENCER: To Bill Ryder. You have performance bonds, certainly, on your RDF receiving facility which you mentioned yesterday. Do you expect to have any problems in terms of exercising the vendor or supplier to meet his performance obligations?

RYDER: Not in the least. Number 1, our specs call for 90 percent payment on delivery. When he delivers that item to the site to be installed by somebody else, he gets 90 percent and we hold back 10. He doesn't get the other 10 until we accept it, so we've got that for leverage. Number 2, we have liquidated damages, depending on the contract price, varying anywhere from \$500 to \$1000 a day if he doesn't meet his delivery date so that's something else. The third is a full performance bond for the entire value of the contract. If the manufacturer cannot meet performance or the company goes under, we call in his bonding company who must complete the terms of the contract at their expense. We've done this before and it has worked.

ALTER: Did you find this cost-increasing? For example, we once asked for a shredder bin on the basis of if it doesn't work and doesn't handle the feedstock to the performance spec, then the manufacturer will pull it. He agreed and increased his price 25 percent to self-insure. I'm over-simplifying, but did you find that these requirements were indeed cost-increasing?

RYDER: I really don't know; I'm sure it must add something.

ALTER: If it were 25 percent, it may be pretty near a tradeoff.

RYDER: If I understand what you are saying, in our contracts which have liquidated damages amounting to, let's say \$1000 a day, the contractor, know-

ing full well that he cannot meet the delivery date, will merely crank enough money into the bid to cover \$1000 a day for each day that he figures he will be late. However, that has its limitations, to exaggerate the case, for example, he can't double his bid price, or he'll no longer be competitive.

SPENCER: We had the same experience. I found that we went to municipal bidding, but our process contractor certainly had the responsibility to do the same kind of things that Bill was talking about. In fact through competition, the vendor's first reaction was we'll just crank 25 percent into the price, and we said we'll just talk to somebody else. And after a while, when you are pricing orders for seven shredders, where the order is a pretty large order, and there are some shredder manufacturers who are interested in doing business, basically the guys who took that position are just thrown out of the office until we got people in who were willing to sit down and wanted the business. That came back to the thing that you were talking about. The guys who were willing to take the risk were the guys that wanted the business, and the ones that were interested in staying in resource recovery and making a good showing. They were willing to add these things in, more at their cost rather than at their risk. Those games were played, I guess I'm saying, but we played them right back, and by and large have gotten now performance guarantees from everyone.

LAMB: I think good buying and performance guarantees are very good procedures wherever they can be effected. I think it is extremely unrealistic to expect that you are going to let your plant startup go to a series of equipment suppliers who have performance guarantees. First, you won't be able to spend the time, because when the equipment doesn't perform it's not always clear why, and you can't afford to have the conferences, and if you've got three pieces of equipment in a row, sit around the table and play ring around the rosie--if mine was working, yours would be, or because yours is not mine isn't. The owner or operator of the system is going to have to be prepared to take precipitous action. He's not always going to have the luxury to insist on the contractor's performance, and contractor's not always going to be performing on a timely basis. For example, in Connecticut, after a certain date, it is required that the bond debt be retired whether or not the plant is operating. So the owner of that plant incurs a cost of about \$10,000 per day when the plant's down. He can't be sitting around with a rinky dink contractor who has got a \$100,000 contract, and think gee, should I spend \$5,000 to replace this part or that part. I really don't think that's very realistic. If you look at the contingent liabilities and costs and damages of not running a plant, there's simply no way that you can take much satisfaction from the kind of guarantees that you can expect from equipment suppliers; they simply can't do it, gentlemen. They can't take on millions of dollars of contingent liability in the sale of a few hundred thousand or million dollars. Their profit margin just isn't there. The owners don't like to take those responsibilities on; I think it's equally unrealistic to expect suppliers to.

ALTER: I'd like to hear from the military on these points, and I haven't at all. I see the Air Force pointing to the Navy, or to the Army, which is it? Who is the senior service here?

HURLEY: I'm not sure that I could address the questions asked with respect to guarantees, but I think it is recognized today the question of can we continue to operate the systems that we are operating and at the same time, what if, indeed, there is some fuel there, fuel value in that solid waste system, how can we best utilize it? So I look at it as a question of what are you willing to do to change the way you are operating today? And to what extent is this a people/machine system? Most of the discussion is about the equipment, but I think you buy equipment when you don't want to do it with people. If we can think that while we want to buy the least amount of process equipment (I'm looking at MRI's chart here), we'd like to get the fuel with the least investment in equipment, which means to me that we have to at the same time look at what people are willing to do at the head end of the system. That may be begging the question, but we have to try, I think, to determine how to get what fuel we can with the least amount of equipment, and try at the same time to see what you can get people to do at the front end--source segregate and other things.

OLFENBUTTEL: What we are essentially looking at in the military, of course, is the lowest capital investment alternative, which means source separation. However, I think we have to recognize that for the military situation we may have to go to other alternatives because of economics, lack of markets, etc. Some of the alternatives may be in regional areas where we have to consider large (what we'll call large) 100 ton a day and larger resource recovery systems. I don't think that is realistic except in a few areas which have been designated by EPA for Federal lead in regional resource recovery because of waste generation quantities, lack of disposal sites, sanitary landfills, and such. We are trying to look at waste heat incinerators, but we're talking about small waste heat incinerators--20 tons per day or something like that. There's just a lack of information on the operating and maintenance characteristics and costs of these systems. I'm just reinforcing what we all have said about all of the other equipment: You can't get a handle on any operating experiences and associated system reliability performance. I'm not saying anything new. I saw a report that came out of EPA very recently for three incinerators which were investigated by a contractor, only one of which was a waste heat recovery incinerator, in Arkansas. The data is really lacking there, also, as to how much it is costing and what the reliability is. The report used four months' worth of data, which is really insufficient to make projections for planning purposes. (I'm sure that EPA will recognize that that's not a really good length of time for collecting reliable data). So, we in the military have to consider all of these options, and no matter where we look, there's just a lack of reliable information.

ALTER: I think everybody is leading down a single path in research needs. Perhaps it can be pulled together. There is perhaps a way of dumping the entire R&D responsibility on equipment vendors. The way of doing it is

called the performance guarantee. Indeed, if everyone had the same liability, if the only way you could play the game, the only way you could sell equipment, was to succumb to a performance guarantee and recognizing this would increase cost, it would be a cost that presumably the equipment suppliers would have to spend in doing their own R&D work so that they could have some assurances about their equipment fulfilling the performance guarantee. I'd like to lead into this alternative to R&D and then into our R&D agenda, by first asking Dave Spencer to go into a little more detail on how they used performance guarantees in Monroe County.

SPENCER: I don't know how many of you are familiar with the Monroe County project, which is not as far along as some of the others like Chicago and Ames and so forth. We're into construction now. We're about 5 percent into construction, with the bad weather in Buffalo and strikes, we are a little slower than what we had hoped. We're maybe a couple of weeks behind schedule. Monroe County took a sort of typical architectural engineering approach, but with a funny twist, in that they wanted to control the job at every stage, which I think makes sense for an owner to do. They also wanted to some extent to minimize the risk on the system contractor, not so much because they cared about what risk he was taking necessarily, but that they felt that that would minimize their costs, which I think tends to be true, that cost and risk are somewhat associated. So basically what they did is they kind of stretched the rules of New York State and selected what they called a system manager who would provide professional services rather than a turnkey or full service contractor who would own, operate, and so forth. They twisted the rules a little bit further and said not only will it be a professional service, therefore buying service on a non-competitive basis, but that as part of the professional service they wanted design and construction management and 5 years of operation. At the end of the 5 years, they'd have the right to bid the operations further to other people. They wanted that contractor to have a stake in the job, but in all phases of the job, so that we'd be worried, scared during the design and during construction to make sure that everything worked out for them, even though they wouldn't be paying us that much for the effort that we were making. We had worked with the Bureau of Mines, I guess we've had a cooperative agreement now about 5 years. The system that was developed for Monroe County was by and large along the lines of the U.S. Bureau of Mines pilot plant in terms of process configuration, although the equipment to perform each of those unit operations was in some cases different. For example, the horizontal air classifier at the Bureau; we weren't particularly wild about in terms of its ability to handle surges and so forth, but yet we had a gut feeling that we should be trying to only do a very coarse shred in the first step of operations and that we should only try to, say, do the total size reduction after we got down. When we knew we had paper, then we'd try to reduce it to a fine size, not when we had run of the mine kind of material. We took the position that, based on the data that we had, we would give a performance guarantee for the total system, that we would market the output products to specific specifications which we had developed based on the work of the

Bureau of Mines, and enter into long-term agreements with buyers of the output products, and then have guaranteed for the county that the process, the total process, would meet those output product specifications. In the event that it didn't, we wanted them to have a stake in it as well, but beyond a certain amount, about 10 percent of the construction cost, that we would to an unlimited extent guarantee making all modifications necessary at our own expense, that we would meet those specifications, and that extended not only to, for example, the RDF product, which has very low ash content and so forth, to meet Rochester Gas and Electric specifications, but even the glass products, where the inorganic content has to be particularly low. So basically that's the approach we took. Then we developed specifications that would pass down the requirements for an individual unit operation directly to the equipment manufacturers. We weren't about to stand in the middle of how an equipment supplier should design his piece of equipment. We did do as Ed Wisely said: We wrote performance as well as hardware specifications, so that there was a performance requirement with bonds, with all kinds of sledge hammers that you could wield, and other liabilities that manufacturers will be responsible for, but not things that they can't be responsible for. We only try to make them responsible for their individual items of equipment, and have passed all that responsibility down for each unit operation to an equipment supplier. In the case of the rotary drum air classifier, for example, if there's a problem with that, Iowa Manufacturing, who is the supplier of it, will have to repair that at their own expense, not from where I sit in the program office, not at our expense. The same thing would be true of Williams, and we tried to tie together subsystems, like infeed conveyors, shredders, and discharge conveyors, so that a vendor would supply a subsystem, which he could be held responsible for.

LAMB: Excuse me, Dave, what was the nature of some of these performance specs, such as the air classifier? Other than mechanically moving and bearings not burning, and motors turning, what other kinds of performance were you able to pass down?

SPENCER: Well, we are passing down that it will take a certain percentage of light fraction, and that it will have no more than x percent free inert material in it.

LAMB: What's the liability if it doesn't meet that?

SPENCER: It's complete with respect to that item of equipment, that if it doesn't meet that, that they would have to replace it totally, at their own expense, refund your money, or to the extent that it doesn't meet the total capacity requirements, there we have an option, or I think we'll have an option, we are still working out the certificates of compliance now. We might just accept a refund of a certain percentage of the equipment price, if that added performance which is specified is determined by experience not to be required.

LAMB: In the worst cases, are you saying that the maximum extent to which the contractor is liable is the purchase price of the equipment? Didn't you say, for example, he had the right to remove it and refund the money?

SPENCER: That's the most that you can reasonably pass down to a manufacturer.

LAMB: That's right, so that he really has no obligation as far as running the plant is concerned, or really any contingent liability.

SPENCER: No, but that's not to say that he doesn't have an incentive.

LAMB: I appreciate that, but again, it's the moral, ethical, professional, reputational incentive.

SPENCER: No, it's not that. It's the withholding, and it's the performance bond, as well as the materials and supply bond. I think with those bonds and with the withholding, you have a sledge hammer. There are certain requirements in there, that if he doesn't take certain actions within given time frames and otherwise, you notify his surety. You let either the surety come in and work it out or the surety [unintelligible].

LAMB: You say in the worst case, the maximum extent of the liability is the refund purchase price of the equipment.

SPENCER: I don't think you can expect any more than that.

LAMB: I'm agreeing with you that that's right, but regardless of what surety says, or the lawyers or anybody else, the maximum extent of the liability which they incur is, in the worst case, to pull their equipment out and refund, so you have a process with a piece missing.

SPENCER: Yes, except what you really have is not that. What you really have is a vendor who supplied a piece of equipment that he's so sure will work, in other words, he's competing pricewise also and lots of other ways. The way I would look at that, Tom, would be that he has been conservative enough in developing the design of his equipment that he is sure that he won't have to do that. Because of the risk that he incurs if there's any probability that he's going to have to pull out the equipment and take it away as scrap, I think that he'll be very conservative in what he supplies and he'll be very fast in terms of making what repairs he can. It's true that if you get to the end point, and you reach a point of impossibility, then it's true you are holding the bag, and I guess in this case Raytheon is holding the bag.

ALTER: Let me have just one more comment on this topic, because we have to get into our research agendas.

CHANTLAND: Who assumes the cost of the delay in downtime? Is that Raytheon?

SPENCER: It depends. In terms of completing the construction, we have a liquidated damages of \$5,000 a day. In terms of equipment items you can't expect a guy supplying a hundred dollar pump to accept a \$5,000 a day liqui-

dated damages charge. We do have some equipment items, where we are particularly concerned liquidated damages, but they are reasonable based upon the price of that equipment. Again, we are not trying to get the equipment suppliers to pay for problems which they can't control; we're only trying to give them a strong financial incentive to rapidly maintain, repair, or do whatever they have to to their equipment. We will also do it for them if they choose.

ALTER: This leads into our research agenda. Now we can do this in one of two ways. We can attempt to go through the MRI booklet that was handed out yesterday, and I am disinclined to do so. The MRI staff has put a lot of time, effort, and thought into the book, and I think it presumptuous of us to sit around and nit pick and criticize. However, it is a starting point. When I went through the MRI book, I was impressed that the objectives were stated and an approach was outlined, where the reader is directed toward what a project might look like. I also think that in a group of this size and sort, we may not be able to do likewise. For this reason, I would like to differentiate between what I call the research agenda and a research program. I think it unlikely that we can design the program today, and we certainly should avoid trying to design the experiments. What I think we can talk about are the categories of items and items within the categories. Yesterday we talked in two categories, you will recall. One is systems process design and the second was selection of equipment/unit operations. I would like to see if we can structure the discussion at this point to research agenda in those two categories. While we are doing this, I ask each of you to take a piece of paper and write your notes as to what you think is important. If you will, we are taking a vote. It's really a consensus. I think when your notes are handed in, they will assist our EPA hosts to distill some sort of final consensus, which I presume will be included in the proceedings and which you will see and can react to. Write your notes as to what you think is important, or if the discussion doesn't get around to your pet subject, write it down. I think if you put your name on the piece of paper, you will also give an opportunity to the EPA staff to get back to you if they have a question. With that, let's try to address an agenda of systems process design, the sorts of information which are necessary to reduce this technical uncertainty, and hence risk for the actors in the field; the municipal official, the A&E, and the systems process provider, and those combinations in between. Let's open the discussion with research items for systems process design. What subjects need to be attacked on a high priority basis, in order to make the judgments?

RIGO: I think that there is something that even comes before those, I think it's a legitimate research need. Some of the work we've done implies that you can almost halve the cost of processing if you can get the households to do a rough sort for you. One that we looked at would split the glass and metals from everything else. This does some very interesting things to your processing line and cost. I think that it's very critical that some good work be done on source separation and degrees of compliance, looking not at

recovering ledger paper, not at recovering newsprint, but instead looking at a segregation technique that makes sense with mechanical processing as a secondary step. I think this is critical.

ALTER: Now wait, before we proceed further everyone ought to be aware of one, the OSW-sponsored work at Marblehead and Somerville along these lines; two, the Swedes started this five years ago, and they have been working on it.

RIGO: They did it in Cleveland up until 1954.

ALTER: They tried something like this in Florida with different colored bags, specifically with aluminum. LA was different, LA was like Philadelphia, where they separate the garbage from the trash. Are we talking about behavioral or technological problems? In Sweden, when they tried to recover the glass, the material needed more processing which might require equipment the same as being installed in Monroe, Hempstead, and New Orleans. Do we discuss, do we start this way? What is the consensus? You haven't touched on "pre-sort" as a first step.

H. FREEMAN: I feel it's a little outside the scope that I would like to hear. I would prefer to hear the research needs directed more towards the machines, and save that for another meeting.

BURCKLE: I'd just like to comment. We are well aware of this need, and the Office of Solid Waste is sponsoring studies in this area. We hoped that based on their study we can compare, get some idea of looking at collection and transportation costs as a trade-off against processing costs. Our basic problem is, we have to fill up the gap on the processing side on the mixed waste, and the information that we get on the mixed waste and processing of mixed waste. Hopefully we can make those kind of cross comparisons.

RIGO: One quick comment. The type of source separation we want to do, when you are looking at simplifying mechanical processing, is different than trying to retrieve components that are individually marketable as received. I'm not talking about that. But the interesting thing is that if we get good unit operations data, then I agree with you, solving the mixed waste problem will give us the data base to solve the segregated waste problem. But if we are not making a strong attack on unit operations, then you're going to have to set up a different type of R&D program, because your processing lines do look substantially different. They use different components, different component sequences.

ALTER: Because of that, I think we ought to take the tack that Harry Freeman suggests. However, the decision by a community to institute source segregation (with or without some processing) may turn out to be a political decision. For example, how do you enforce the requirements that people (and especially old people) separate their refuse? Return to systems design and what information is necessary. We went through many alternatives yesterday.

Let's try to assign priorities. For example, George Trezek presented an attempt to compute the energy of various combinations of unit operations. Is this the sort of task that needs to be continued? Let's start with the prejudiced viewpoint, George?

TREZEK: No comment.

BENDERSKY: I'm going to put George on the spot here. I think the work that George did on shredders is indicative of what can be done in other unit operations equipment. I think it's directly applicable, for example, for the study on air classification to do the same kind of manipulation George did on shredders, do it on air classifiers and perhaps some other basic unit equipment. In other words there are variables that are controllable in these pieces of equipment. There's fundamental information to be gathered. Sometimes you can't put it into a nice, neat equation, but even when you can't basic information is needed on equipment like shredders and magnetic separators and other items. I suggest that more thought be given to similar work on unit operations at a laboratory level as well as full-scale and other tests.

TREZEK: We are going to do some similar kinds of studies on densifiers--pellet mills, densifying, this kind of thing--and probably we will evolve similar kinds of curves so that we can predict the final step in the process of what the densifying step adds to the energy.

ALTER: Let me comment a bit on the air classifier. We attempted such things, as David said, and found we were frustrated by the inability to easily change design of the air classifier at a reasonable throughput. Reasonable, I'll say, is 10 tons an hour, but really higher. As was discussed yesterday, in order to understand the unit operation, you almost have to destroy it. You have to examine orderly change even if it results in a detrimental performance, and this is different from going into a plant and trying to tune to optimum performance. Indeed the kind of data that George has been able to obtain in shredding is difficult if not impossible to get in a plant. We are proceeding with an air classifier by building our own. It's a vertical zig-zag that can be easily changed in terms of width, depth, angle of zig-zags, number of zig-zags, feedpoint entry, and the point of reintroduction of recycled air. It's a research 10 to 20 tons per hour unit. I hope we have the time and resources to fully utilize this device. In researching this unit operation (or others), there are different approaches representing a spectrum of research philosophy. Perhaps this spectrum extends from plant operator through designers and equipment vendors, government laboratories, and universities with their need to educate.

TREZEK: I think that our work has been useful related to reality.

ALTER: It's absolutely useful. I want to construct the spectrum. I'm not going to say what's on the left and what's on the right, or what's right and what's wrong. One part of the spectrum is university. Let me assert

that another part of the spectrum is the occasional measurement in the plant, or somebody writes a paper in Public Works Magazine, or such, where they purposely do not go into a lot of detail, and maybe they don't have the detail to go into. What some of us have tried to do is something in between. What we've tried to do is take enough data to relieve anxiety and show that something can be done without getting a lot of detail, a sort of middle ground, which I hope is useful. When we start constructing these research agendas, how much detail do we go, where is this spectrum? I don't mean to imply you can't even go further in the sort of detail, as George did. Let me go back to systems process design. We talk about alternatives. Given a number of unit operations, A, B, C, and D, how far do you go in looking at the combinations and permutations of how you might arrange these? Do we go to one end of the spectrum, to the other end, which is most useful?

H. FREEMAN: I wanted to ask a question, Harvey. Just from the conversation that I've heard this morning, I haven't heard a whole lot of technical obstacles brought up. We seem to have gotten off of that rather quickly and into other things. What I'm hearing now is the need to evaluate these different pieces of equipment. I guess my first question is: Am I hearing this right, am I hearing the users say there are really no technical obstacles, we just need better information on what we have? My second question is: In setting up a research agenda, are we drawing our lines too narrow to just talk about going out and evaluating what is there? I guess I would like to hear that tossed around a little bit.

HURLEY: I think we are trying to apply what we have been told is available. It's other people's experience, it's EPA knowledge, it's College Park experience, and with a guideline now that says we must develop plans for resource recovery. What have we got in what we call the small-scale, or suitable for a small-scale operation. I think the Navy program is one that says let's apply what is known now. That's what we hope to do, with a field experiment working on actual waste, not in the laboratory, but get out there on a [unintelligible] operation and see what it costs and what the problems are and whether you should give up the ghost and just join all regional systems, or whether you can in fact utilize it economically.

H. FREEMAN: I can appreciate that's probably what most people here are interested in, but I would hope you wouldn't lose sight of the fact that we are talking about a research program. At least here in this room we have the luxury of being somewhat outside the lines and this may indeed be narrowed when David Berg's group gets restrictive. They restrict us and they in turn are restricted by a bigger restrictor, and this goes on. I think here we should keep in mind that we have a big world to talk about. Let's don't just talk about evaluating the XYZ shredders, unless of course that is the optimum that we can ever expect from all shredding operations.

WISELY: There appears to have been at least a tendency in this group to at least refer to the desirability of deriving rather precise knowledge in a

very, very imprecise field. From a practical point of view, from a standpoint of applying processes such as we are discussing here, this precise knowledge really isn't worth much. Some of the more pragmatic people on the other side of the table referred to this to some degree yesterday, but I just wanted to bring it up again. There are types of equipment that have some potential desirability in application--small ones such as yours, Mr. Hurley. To the best of my knowledge, there are not data as to what kinds of information can be derived from those. I was going to suggest that rather than concentrate on the XYZ shredders as Mr. Freeman talked about, that you address yourself to some of the kinds of equipment that may have potential and may be in the long run far superior to anything we know about right now. We know what some of this equipment is, but we don't know how it performs. I'd like to talk to you about that some time, Harvey.

ALTER: Thank you. You raised a very good point. You talk about over-preciseness, too much detailed information. Then what is the type of information that we need?

WISELY: As the gentleman over here mentioned yesterday, what we need are ranges of information for various applicable parameters.

LALKA: A lot of data has been accumulated on pilot plant operations, small-scale shredders, that type of information. Listening to Peter Ware, he indicated that his full-scale shredder is not doing the job of another unit that apparently is comparable, plus he feels that his air classifier is more a state of the art thing rather than something you can write equations around. I think rather than concentrate efforts on gathering data on pilot plant units and smaller units that have a scale-up problem we should concentrate efforts on units that are in full-scale plants, and take a look at what kind of information we can see from an actual operating plant. On a pilot plant level people have a tendency to synthesize the feed material. It's not like a packer truck is backed up to a pilot plant, and you put in real refuse; sometimes it's kind of a synthesized feed stock.

ALTER: You'll get a lot of disagreement on that.

LALKA: Well, there could be a lot of discussion I'm sure.

ALTER: Roger uses real packer truck refuse. We use real packer truck refuse. George uses it. We don't know how to simulate garbage.

LALKA: Right.

ALTER: We don't know what small-scale garbage looks like.

LALKA: That's one of the problems of scaling up from a pilot plant. Every city has a different type of refuse, and presumably the operation of this equipment varies tremendously with the composition of the refuse. I think you could get some decent information just by looking at various parts of

the country, that, for example, have full-scale shredders in it. If you could just compare all of the information on those units, you'd probably have a pretty good idea of what these units can do.

HASSELRIIS: I would go back to George Trezek's presentation as being a good example of what can be done by putting together a mathematical model of what's happening and of the utility of doing that. By looking at that presentation, you can see why and how different shredders work for the first time, once that clarification is made. But what none of us understood, probably, in the beginning was what statistical distributions of particles really mean, and how to work with them. What that presentation shows is that the statistical curve is just an equation, and the equation can be applied with another equation, and they come up with answers and correlations and solutions. That procedure is very powerful, and it eliminates this need for preciseness which we've been brought up with. If you wanted to apply the same thing to an air classifier, I think you could find again the same things would apply, that there's a mathematical model which would give you some indication of what the implications of scale-up are. If you find that a particle has to pass through a 2-foot bed instead of a 6-inch bed, obviously it's a very, very different thing and I think it has some relationship to the fact it was a 2-foot or 6-foot, or whatever. I think this is something we can get a very great benefit from the university type approach of a real study of the mathematical principles, the theoretical principles that we are really working with. If that model is put together, then each of us as users can use it to test our own information and to see how close to perfect we are. For instance, if you did it with the shredder, we find out that if one shredder is actually doing three times as good as another for some reason, you'd know it right in the equations that it was three times as good or three times as bad, and if you say that's my potential for improvement. If we already know there's no further potential for improvement because it's inherent in the operation, we wouldn't try to improve it. That's very important to know what our entropy level is or the point of what is the most possible performance that could be achieved from a piece of equipment and how far we are from it. We'd know how far we are from it, we'd know how much we are willing to invest and how much improvement we could expect. So I think that's a very important aspect--fundamental research that really comes up with the model that we can use to put various inputs into and get some kind of an output, a useful output.

DE CESARE: Harvey, I believe many people here know of Taggart's book on mineral dressing. They go around to existing plants without data now and take machinery that is in operation and put down the full range, what that machinery is doing in its installation. If EPA has money I don't know why they can't get a mobile research lab set up to go out and monitor existing shredding stations. Whether they have to have funds to pay each shredder's installation for cooperation or not I don't know. Go there and find a method of attaching equipment to monitor kilowatt-hours, so they can chart kilowatt-hours versus feed rate, versus size of shred, versus moisture

content, if possible. Perhaps at certain shredder installations they can even vary sheave sizes to get speed changes. You have to work with the people that are running the shredder to get them to cooperate, get good information on maintenance and reliability, this type of thing. This would be an intensive program that should be done on existing installations and you'd be able to get quite a display of information this way.

ALTER: We are going to discuss the Taggart approach, I promise you, but let's finish this conversation first.

BURCKLE: I'd like to go back and speak to the comments that Ron Lalka made a few minutes ago, because I'm very concerned about these two points. One is scale and the other is the nature of the site specific characteristics of the waste. Because these so influence any kind of research program one sets up, be it a pilot plant or field test situations, in terms of transplanting that data for use to another site. If our data is site specific and cannot be translated, there's no sense in spending the money to do the work, in my opinion. Now, in terms of scale, I think there is a need to deal with the scale factor problem, because not all plants are built at the same size. It depends on the community needs. That's the one aspect. The other aspect is site specificity. If we're stuck with saying that the data that comes out won't give us the optimum design information for a given plant, what do we do about this? How do we attack this problem? Is it really a problem? If we operate on the band width concept, if we properly structure our band width by first going into a number of communities and looking at how similar or dissimilar that waste is to establish our band width, is that a legitimate approach to structuring our research program, or is it even more important that we do that? I'd like some of our comments at this point from the A&Es to deal with this problem, if that's possible.

FAY: I just had one comment. I'm not sure that the shredder people would look with great favor on EPA coming out and testing their shredder and publishing all the data. The only way you got automobile mileage is pass a law saying they got to do it. While I can understand the desirability of this from this group's aspect, I don't have much hope for it.

ALTER: I don't think we should dwell on it because George presented his information, and we are going to publish ours. We went around, as I said yesterday, to 10 operating commercial shredders; that data will be published. I think there are other unit ops that need more of this kind of attention. Shredders are only an example of how it might be done.

RIGO: I understand statements that we really don't need precise data on what the components do. Today that's true. Looking at what we would like to do in selecting plants 5 to 7 years from now, and that means we have to start today getting data, it isn't true. If we can characterize the waste, and I don't mean a point, I mean get a good statistical description of what that waste is and get a good statistical description of what the unit operations are doing, it is possible to make an intelligent design using

stoichiocastic design procedures that will come out with the "optimum" plant. That plant will not be right for any condition, but on average over the year and including projected changes in waste composition, it will be best. There is a very strong need to get good data and not just something that says well, we are going to fly 70 percent of the stuff that's thrown into the air classifier. We also need to be looking at new unit operations--ones that are not now applied, and we need to obtain data so that when we do go out in the field (and this is lab data) that we only need to get a limited number of data points on the full-scale operation to verify the results which use the lab data (where it's relatively inexpensive and convenient to play) to get shapes of curves. When you go out in the field, you validate the shape of the curve. So you need a laboratory effort in conjunction with the full-scale application.

ALTER: We talked about this yesterday--about compositional data, good data and bad, and so on and so forth. I have a personal prejudice that says this is a cop-out. We can do all of the detailed compositional analysis we want to do today, and we've frozen one day out of the year of this year. I don't know how to project future waste composition; rather, we must have the ability in a processing plant to make adjustments to change. Am I wrong? Do we take Greg's approach, or do we take the approach of a general sort of compositional data, you need the band width plus or minus. He wants to narrow the band width.

RIGO: No.

ALTER: Is there then a research need to get better data or not?

BURCKLE: Harvey, I think this breaks down into the question that we are dealing with here of Greg's point that the designer needs some sort of model, if you will, so he can predict the performance of the equipment. It seems to me (and please correct me if I'm inaccurate) the first thing a designer needs is to be able to sit down and draw a process diagram, which says I need this kind of performance out of each unit operation to get to this kind of quality fuel and this production rate of fuel. Then he needs to be able to fill in those blocks with specific pieces of equipment that will give him the performance that he needs, taking into account the problem of the variability of the waste, both from community to community and also in time. I think that that's the overall envelope of the problem that we are dealing with, putting a preprocessing system in the field ready to operate. Now on top of that we have to impress the fact that we've gone perhaps 80 percent of the way to a totally operating system, and then we have the shakedown period during plant startup. Please correct me if I am inaccurate or have only stated the partial case. I'd really like to hear from the experience of the A&Es and the people that have been involved in the past in starting up these kind of plants. Is this or is this not the kind of procedure that's in general followed? Because I think that bears on our informational needs.

LAMB: My plea is for more fundamental data and on a unit operation basis. You might make an analogy to a barrel of crude oil in a refinery. You don't

tell a refiner what the mix of end products ought to be from that barrel of crude oil he has. He needs the tools, distillation curves, hydrogenation curves, and things like that, and he can make his own business decisions as to how he wants to put the pieces of the plant together to optimize what he thinks is his product mix. I think we need exactly the same data. I agree with Harvey, I think the compositional thing is a cop-out, because there is no way to deal with it anyway. Your day-to-day variations are far going to exceed any precision that you are going to be able to achieve in the data. We ought to know if we primary trommel what kinds of separations we can get, and what's going to be the composition of the materials that pass through and what over. We ought to know that maybe as a function of rotational speed or hole size or are deck screens better than rotary screens. You can go down--if you want to dry, how do you dry, do you dry counter-currently or co-currently, do you dry while you aspirate or do you dry in a rotary dryer? What are the tradeoffs? Where's the kind of basic data where a designer can sit down and hypothesize the design and say if I get this heat transfer rate in this particle size at least I have a feeling that the thing's going to be about 10 feet in diameter and about 40 feet long. Fine, then I can go to the system supplier if I want to buy one and he's going to have a model in his plant and we're going to ship him some material and we're going to monitor the performance on his piece of equipment. But we've done a lot of thinking and a lot of screening before we've gotten to that point, and that's the kind of data we don't have. If we flail with a flail mill, is the glass a different particle size and if that is, does that simplify or complicate a glass recovery scheme? I hear the concern from the pragmatists that we don't get too theoretical, but I think one thing we could all agree on in this business to date is we haven't erred on the side of being too theoretical.

BURCKLE: Tom, yes, I agree with what you said, but I think maybe I don't quite understand one part of it. It seems to me that the performance of a given unit operation is going to be somewhat subject to the feed material that's coming into it.

LAMB: It is.

BURCKLE: What I'm driving at here is, I don't see how we can get over the process part, for example, where we pre-trommel before we primary shred. I think we have to look at complete sub-systems, if you will, or the process type research in addition to the unit operations.

LAMB: What do you mean by a sub-system?

BURCKLE: Take for example sub-systems, I would say that one sub-system might be to look at pre-trommeling shredders and some sort of size classification system on the outlet of the shredder with a recycle. That might be a complete sub-system.

LAMB: You don't have to test that all together, I might argue, you could test that by piece and pretty well predict closely enough for your needs what's going to happen when you tie the components together.

BURCKLE: Only if you can control your inlet feed. What I'm saying is, I suspect the performance of a primary shredder and a classification system might be considerably different than if you pre-trommel, primary shred, and classify.

LAMB: I suspect it will be considerably different.

BURCKLE: I don't think that if we test just trommeling separately from the shredding that you are going to be able to marry the data.

LAMB: Well, my suggestion would be, for example, if you designed your research program properly, when you are evaluating the shredder you would hypothesize first. You might want the trommel to hypothesize, then the range of conditions you want to test for the shredder. Maybe we are arguing about the technique, that you do it all at once or by pieces. I guess I don't care, but it does seem to me there's a lack of basic design data. Evaluating equipment, we're all doing that now. That's not going to benefit any one of us who's out running a plant for the next 5 years because you're not going to have any data for it.

CAPPS: I'm working with Steve Hurley in the Navy program trying to sort out R&D problems that we can tackle. I share Harry Freeman's view. I haven't heard any technical obstacles that would be approachable in any system that I have thought about to date. What we have come up with as a conclusion is that there is so much uncertainty in this whole system that we have to set up a field laboratory, a field test evaluation, so that we can define the R&D problems so that we can then get at them. I think this is somewhat the approach that NCRR is taking, and I would hope that we are paralleling or at least complementing, what NCRR is attempting to do. I think that John Burckle's views of the systems approach is absolutely true. Our view, and I think that we are evidencing it right here in this meeting, we are having great difficulty identifying those technical obstacles. The strategies that we hope to do is to identify them in the laboratory of the field proving ground, if you wish.

SPENCER: I think your problem is a little different, because you have the opportunity to do a certain amount of hand sorting, so that you can probably work very effectively at a smaller scale. I think with the large scale, other people are doing design and systems supply. I want to get back to one of the things Roger De Cesare said, and I know it's a problem Harvey Funk and I talked about before, and Tom Lamb is saying the same thing. We don't have basic design information. Frankly, my own opinion is: You know I'd like to see a plant that had in the front of the line had a large vertical shredder, and next to that had a horizontal hammermill, and next to that one of these slow speed grinders like they have in Europe with different conveyors that can feed the four different types of air classifiers, one being a rotary drum, one being a variable zig-zag, one being something different, and then having behind that, let's say, trommels, and have enough space and enough flexibility that you can then interchange things, try a

coarse shred material with various size grates, and feed that into the various air classifiers, and develop a handbook like Taggart that says, when you do this you can anticipate this kind of a result. You don't know it for a certainty, but when we did it this way this is what happened, and you have that kind of data and you have the operating data. There's no basis for anybody to do a really rigorous design. Even a bin prefers cans. You don't even know exactly what the angle should be, or you don't know how you discharge from the bin, you don't know what the gate should be, and you're not sure whether you're going to have a bridging problem. Those kind of basic fundamental things don't exist. What's worse is we don't even--here we are 5 years down the pike and we're still not even starting to do something positive to get that basic information. It's true, we can look around at various systems and say (and Taggart does this also) well, so and so's system, when they did this they got this result, and in so and so's system, when they did this they got that result. That doesn't always help you, though, as much as the more basic information that says when you do these kinds of things using this piece of equipment, this is what you'll get. You can expect to use so many balls per hundred tons of material; you can expect to use this amount of electricity; and when you shred and you are shredding to this size, you can expect to spend so much material on retipping your hammers; you can expect to use so much power per ton shredded, when you are shredding to this size range; when you change the size range you can expect the following. You need that information to do a sensible design, and we don't even have the mechanism by which to obtain the information. What's worse is we're not even starting down the path yet to develop that mechanism, that research tool, that will allow you to do it. The thing that scares me worse than anything else is that the total budgets that I see being made available to resource recovery are not sufficient to ever obtain that information. We'll look at that one, we'll look at that one, and we'll try to steal little bits and pieces. When you're all done you haven't really evaluated the thing. Evaluating composition doesn't help me one bit. A lot of the things that you are doing don't help us design systems and I don't think they help the A&Es design systems either. They are nice information but in terms of doing real things at fair scale, it doesn't help us in terms of what we have to do when we have to buy something now, and it's going to be at least 5 years to get this information anyhow, at least, and it might even be a little bit longer. You've got to start somewhere. The first place to start is with a realistic expectation of how much it's going to cost to do something that's worthwhile.

LINGLE: I think what I hear from the various comments in the room regarding how we collect data, what type of data to collect, at what level of detail, and on what size facility is that at this point in time there is so little information available, that we really need a whole range of different types of data collection. The different mechanisms for collecting the data and the different kinds of analysis that you can do are going to be useful to different people to varying degrees. Maybe there are three or four steps. One step might be simply to gather data on the overall performance of total plants or total systems, new systems coming on-line.

That sort of data is probably particularly of interest to the municipal sector. They want to know are these plants working, what do they cost, what is their overall reliability, what sort of emissions do they produce, do they meet product specs. This sort of information is needed. It may be of some use to design engineers, but probably more limited use than some other types of information. As a lot of people have said, there is not much flexibility for really varying parameters to get individual performance data on unit operations. Perhaps another level of data would be to investigate particular unit operations at various installations. For example, you could pick out ten shredder operations in the country and collect performance data. That's at a slightly more detailed level, and it starts to become more interesting to the design engineer. A third level of data is to set up some test procedures, whether it's in a pilot plant or whatever, and get the kind of data that George Trezek has gotten on unit operations--really develop some basic data. That's certainly of interest to the design engineer. There may be a fourth step, and I think Harry Freeman was alluding to this, which is that maybe we also need to forget about the existing equipment to an extent, or say there's some need to just develop some new items of equipment. I think we are trying to find an answer, and there are really a lot of answers. I think we need all of this kind of data; we need to develop programs to get it; we have to realize that different data is useful to different people.

WALTER: I'm glad that Steve knows what he's hearing because I'm not quite sure I know what I'm hearing. I hear Harry Freeman take off on one of my pet subjects, which is the thing that Steve ended up with, that really shouldn't we step back and take a look at this very heterogeneous mass that we are trying to process, and apply some thought to what the various things we want to do to it are, and then try to develop equipment specific to that mess that we are trying to play with. Particularly I think that we should (at least I remind myself when I read some of the original Bureau of Mines reports) remember they very candidly said and I think very properly did, took existing equipment and tried to modify it to a new feed source. Maybe we have to look at the feed source and build the equipment to fit the feed source. Not saying that we should not continue where we are, that is continue to look at the equipment that's now being used.

ALTER: I'd like to postpone this discussion just a moment and try to get to it through a different route. Also, I want to alert everybody to keep to the research agenda and not a wish list. There is a very important difference. Let me suggest that we try to approach this a little differently. I'd like to try an exercise. Turn to pages 13 and 14 in the MRI book [see pages 158 and 159]. MRI has outlined the research needs by category. I'd like to suggest an exercise. Number the general categories (shredders, magnetic shredders) Roman numerals I, II, III, and so forth all the way through Economics on page 14. Then, I'm going to ask that you choose five, your first, second, third, fourth, and fifth choices of research needs, and write them down on a piece of paper. Put them in order that your first choice is what you regard as most important. Let's delineate what the

items on pages 13 and 14 might be the five highest priorities. But let me also tell you where I think I'd like to see this discussion lead to. I want to return to what Roger said in terms of the equivalent of a Taggart, Taggart's Handbook of Mineral Dressing. It's a thick book and a lot of it is still up to date, even though the first edition was 40 years ago or so. It's a type of handbook like a Perry or a Marks. It's the equivalent of a design handbook, a where we're going or what we might expect handbook. What are the most important things to go into the equivalent handbook of resource recovery? Of the 40 titles [pp. 158-159] where do you think we should start? Put down your first five choices of what should be attacked first, then put down your first five choices of the things that shouldn't be looked at, what do you not like?

LISTING OF RESEARCH NEEDS, BY CATEGORY

I. General

1. Determine Optimal Arrangement(s) of Unit Equipment.
2. Study Emissions from Processing Equipment.
3. Determine Effects of MSW Characteristics on Processing.
4. Evaluate Other Potentially Applicable Equipment.

II. Shredders

5. Compare the Performance of Various Types of Shredders.
6. Determine Maintenance Requirements of MSW Shredders.
7. Determine Optimal Hammer Design(s) for MSW Hammermills.
8. Establish Shred Size Requirements.
9. Evaluate the Cost Effectiveness of Single Versus Multiple Shredders.

III. Magnetic Separators

10. Determine Effect of Magnetic Separation.

IV. Air Classifiers

11. Determine the Optimal Operating Conditions for Air Classifiers.
12. Compare the Performance of Different Types of Air Classifiers.

V. Screens

13. Compare the Performance of Coarse Screens.
14. Compare the Performance of Fine Screens.
15. Determine the Effects of Pretrommeling.

VI. Dryers

16. Determine the Effect of Drying on Bacteria and Virus.
17. Evaluate the Effect of Drying on the Efficiency of Air Classification.
18. Evaluate the Effect of Drying on the Storability of RDF.

19. Evaluate the Effect of Drying on the Combustion Characteristics of RDF.

VII. Densifiers

20. Determine the Optimal Operating Conditions for Densifiers.
21. Determine the Specifications for Densified RDF.

VIII. Conveyors

22. Determine the Optimal Operating Conditions for Vibrating and Pneumatic Conveyors.
23. Compare the Performance of Conveyors.
24. Compare Air Transport Systems.

IX. Storage and Retrieval

25. Compare the Performance of Various Storage and Retrieval Systems.

X. Receiving Facilities

26. Evaluate Receiving Facilities.
27. Evaluate MSW Segregation Prior to Processing.

XI. Controls

28. Characterize Present Control Systems.
29. Determine the Effectiveness of Present Control Systems.

XII. Fire Protection and Explosions

30. Study the Incidence of Fires in Solid Waste Plants.
31. Determine Fire Resistance Characteristics of MSW Processing Equipment.
32. Determine the Effectiveness of Fire Protection Systems in MSW Plants.
33. Study the Incidence of Explosions in MSW Plants.
34. Determine the Effectiveness of Explosion Protection Systems in MSW Plants.
35. Evaluate Spillage and Dust Controls.

XIII. Economics

36. Develop Effective Accounting Method(s).
37. Establish Capital Costs of Processing Equipment.
38. Determine Economic Life of Processing Equipment.
39. Determine Equipment Operating and Maintenance Costs.
40. Perform Cost Effectiveness Analysis.

Source: "Study of Preprocessing Equipment for Waste-to-Energy Systems: Summary Material and Research Needs," Midwest Research Institute for Environmental Protection Agency, Municipal Environmental Research Laboratory, Cincinnati, Ohio, February 1977.

H. FREEMAN: To exercise my prerogative as a member of this group, I would like to have heard what Don had to say. Maybe it was because he sounded like he was getting ready to agree with me [unintelligible]. The second thing is, I think in just the exercise you are going through here, it's kind of the same thing. I don't see a big category called "Other" or "New Ideas" or "New Studies" or whatever, so I feel you are restricting us to exactly what he was saying at the beginning.

ALTER: You can do it with a third category.

H. FREEMAN: I would have liked to hear him make the point.

ALTER: I agree with you. You jumped me completely, because that was my next step to stimulate the study. Has everybody got these 10 down? I suggest 1 through 5, which you think are high priority, the highest 5 priority in your judgment. Then 1 through 5 of which you think are the lowest priority, where 1 would be the "pits."

WALTER: These are in terms of the general categories, of general shredders, magnetic separation.

ALTER: If you like, but I would hope that maybe you can do it of the 40 categories.

BERG: You are talking 40, instead of 13 now.

ALTER: Or if you feel like you can only do 13 in this time period. I think that the EPA staff can analyze the consensus for that. John Burckle has assured me that he can. All right, now to get to the third category. Don?

WALTER: The third category contained number 1 on my first category, which was number 41 [unintelligible].

ALTER: My third category is as Harry was talking about. What's not on the list? Now let's do this in terms of a need and not a wish list. What might MRI have left out? What's your pet peeve?

SJOBERG: This group has been looking at this basically as a plant. Everybody who is involved in this business has to approach it as a business unit which is from the time you receive the material, the transportation at the transfer station, transportation, the plant, the economics of the plant, and what you do with the products that come out the other end. We have not found it very difficult to assess what plant operations and the equipment and the costs should be. I find the biggest problem we have found to be able to assess is when you go throughout the country to different prospective projects, is what and how is the power company going to be able to utilize this material? Because in order to make this industry viable, the economics of it is such that you have to have, as we have in our case, a [unintelligible] and they have a dearth of information that they are lacking. I think if you really want to apply where the priorities are going to be for research, to make this industry viable, you have to put it there.

ALTER: That's the next work shop: Talking about mechanical processing up to that interface. John tells me the next workshop will talk about that need. You have three categories now, and as soon as everybody is finished we'll talk about how to get the information; how to translate this consensus into an action plan. Now one other requirement which would be helpful. If you don't wish to sign these things (I hope you will), please indicate your viewpoint. Are you municipal, A&E systems designer, interested observer, however you'd like to characterize yourself? I'd like to talk about one aspect of how these data may be taken. We've talked about design; we used the term design handbook yesterday. The subject of Taggart's Handbook of Mineral Dressing came up today. In either case we're talking about a design book for resource recovery. Of course in the next few years it's going to be thin and loose-leafed, but a book that we could use for guidance. It might include: What might you expect, what did other people experience, what are the principles or equation you might use to predict where you are going. Now in order for the book to be assembled, we need cooperation, we need comparable data. I'd like to discuss a pet subject of mine and find out if there's agreement or not. Let's discuss how comparable data might be obtained so that data from Institution A may be compared, if not combined, with data from Institution B, at least that the data were gathered by the same methods. For example, Tom Lamb mentioned if you are going to "pre-trommel" over a range of rotational speeds and range of hole sizes, it would be useful if people would investigate and subsequently publish at least over the same range of speeds, hole sizes, etc. Thus, we could have some guidelines, of course not mandatory, but guidelines as to how data may be taken. Question: Is there agreement or disagreement or comment on the philosophy of such an approach?

H. FREEMAN: That philosophy being what, that they should be comparable?

ALTER: People should be aware to take the information, the same or about the same way. I don't want to mandate a particular way, but there ought to be a recommended method for investigating devices and unit operations.

CHANTLAND: Harvey, don't you have to create a matrix of the boundaries that you are going to work within?

ALTER: Precisely.

CHANTLAND: Then when you get that agreement, then I think everybody mostly could work with similar data.

ALTER: I take silence to be assent; let's move on to the next item. How to do it. Now the next item then is how might we arrive at the matrix, as Arnold called it, as a guide for investigators in the field, and ultimately then, the design book or handbook of information which people can use. It was suggested yesterday, and I'd like to open up for discussion, the concept that this group be the nucleus for a number of committees to draw up such matrices or such guidelines. This is, of course, voluntary. Perhaps the

organization is a subcommittee on shredders. Another on air classifiers, and so forth.

OLEXSEY: I think that's an excellent idea, because one of the things that was brought up very much in the course of the meeting was a lot of people have proprietary type information and are not willing to share it and you can understand that. It seems like a committee to touch across various companies and/or industries and somebody may have some industry funding like EPRI or NCRR, outfits like that, so that in areas where the government hasn't been able to provide information, where these companies can get together and even fund, because we are all looking at the same machines, the same processes, and we're duplicating efforts internally.

ALTER: Any other comments on this concept?

HASSELRIIS: I think it's a very sound idea to set up this kind of communication whereby, while my information may be proprietary internally, I know perfectly well what I can put into a framework that's been agreed to by everybody. I can see why, for instance, in the case of a trommel system, there's the possibility of our feeding that type of information, everybody feeding it, and the whole thing making some sense. It's the type of machinery where I think that it's possible to do that. The only difficulty is that, again, we are confounded with a total different nature of the material, and we may not have the money to analyze the material on the basis of which the data was produced. That would mean that whoever had the money for that type of information would add it, and then we maybe would be able to guess at what our analysis was, close enough. It's good enough for our purposes, so we can trade something useful to other people at no loss to us and at the same time we'll get back a return for our efforts to try to understand it. In other words, it's not strictly a one-way mirror. It's a valuable exchange of information, but it requires an external matrix that gives meaning to our information and gives meaning to what we get back. That's what we're trading.

ALTER: That is something which has to be raised in these subcommittees, which I'll return to in a moment.

FISCUS: One thing I wanted to mention--a fairly common sense sort of thing, but I did want to bring it out--if you are going to develop standard methods of investigation, I think there's two points you have to consider. One is that the methods have to be fairly specific. If you keep them too general, then there is enough variability in a general method that it doesn't get equally applied in all cases. The other danger is that you have to be sure that these methods are minimum recommendations or base line recommendations, leaving room for investigations of unusual occurrences. If you don't do that and make sure everyone understands that, then maybe you're evaluating refuse processing plants and everybody says o.k., I've done what the committee recommended, and that's all that we have to do. That does not necessarily tell the whole story. It's the design philosophy, I guess, is what I'm trying to communicate here, of promulgating recommendations for investigation.

ALTER: We suggest to break into such committees. They might be organized into the following categories: I think we may need only three or so such ad hoc committees, maybe more. One on size reduction, one on separation, and perhaps we divide the separation committee further into air separators, mechanical separators, i.e., screens, etc. Others might be nonferrous separators or magnetic separators or glass separators. Bill, maybe it would be good if you could write that on the chalk board. [See Table 1].

Table 1

<u>PROPOSED COMMITTEES</u>			
I	II	III	IV
Size Reduction (Densification)	Separators	Materials Handling	Drying
	1) Air		
	2) Screen		
	3) Other		

RIGO: Why is size reduction singular?

ALTER: It's generic.

RIGO: Separation's generic.

ALTER: Suggestions for other ways of organization. Materials handling has been suggested. We heard densification, what else? Drying has been put down.

LINGLE: How about process control?

BURCKLE: Process control is what you do, once you've got these answers.

ALTER: We're talking now of methods leading to evaluation. Storage is in the materials handling category, and Dave Bendersky has included it that way in the MRI list. We are talking about methods of evaluation. There's room for distinctions here, I want to make certain they are distinctions with a difference. There are methods of fire protection and explosion protection; perhaps they haven't been applied; perhaps we don't know how to apply them. Now if we learn how to apply them, should they be evaluated the same way? I'm referring to means of evaluation and measurements of performance, not toward invention.

SJOBERG: You're going to have to itemize what techniques are available. One of the most critical parts you have relative to these plant operations is not to lose it.

RIGO: Harvey, we just finished up something from the Navy. We had to take garbage processing systems all the way through materials recovery, and break

them out into nine modules: Groups of things that did roughly the same thing. Maybe that would be a good way of helping the breakdown. The module systems that we came up with were receiving, size reduction, combustible separation (you might argue with the word combustibles). From there we went down into what we called an RDF preparation step (upgrading of some form) densification, and storage. We also looked then at magnetic separation, non-magnetic separation, and glass. Now, this gives us nine groups of things, each of which are going to have characteristic evaluation requirements and procedures in reporting requirements. Maybe that's better than trying to go to this type of breakout. I know it's more detailed.

ALTER: I have to tell you that I fear too many. If we are going to break into committees, the people who will want to attend and participate will have too large a drain on their time. If there were, say, one committee for materials handling, they in themselves could give priority order. Whereas if there were one committee on materials handling and one on storage, etc., these committees would involve all the same people interested in the general category of materials handling. Where does densification fit in? Let's make an arbitrary decision: in size reduction?

BERG: There's one whole set of things I think you are missing, and that's your process controls, including the emission control questions and what have you there.

ALTER: No, as I said, I think these lists refer to methods of evaluation, not existing methods of process control or measurement, so do not include existing methods of emission control. We're talking only about methods of evaluation, what measurements are to be taken. For example, in emission control, I think the measurements which have to be taken are clear, because of law and regulation.

BENDERSKY: Harvey, I know you didn't want to get into this economics, but I would suggest that before too long consideration be given to the combination of cost along with technical performance. I think the evaluation of equipment performance always comes down eventually to dollars per ton.

ALTER: I think that's part of the matrix.

BENDERSKY: The only thing I was going to suggest was the possibility of an economics group.

ALTER: All right, what does the group feel? Do we get into uniform cost accounting procedures; that would be the method of evaluation of economics?

BENDERSKY: That's just one of many things that need to be done.

LALKA: I think the A&E people have different interests than the municipalities. I think if I were an A&E, I'd be interested in getting all the design information I could on a piece of equipment, but from the municipal

standpoint, the thing that would interest me most would be the cost, the O&M. Once the plant has been built, and it's turned over to me, then I have to start worrying about dollars per ton. So there's quite a difference between the two interests here. I would be concerned about the environmental considerations once I have the plant, plus all the costs and power consumption, etc.

WALTER: I would submit to you that economics is a matter within the category, because if you can sell something for a buck a ton whole and it costs you \$2 a ton to make it small, and you only benefit by a dollar a ton when you make it small, you don't want to make it small. So you really ought to look at economics in terms of size reduction. Similarly you should look at economics in terms of separation. Do you get anything back for your separation? Your economics relates to each one of those phases and should be looked at that way, so you make discreet judgment as to whether you should even be doing this stage or not.

BENDERSKY: I accept that if you will include economics within these groups.

WALTER: Sure, they're essential in the end.

BENDERSKY: Not just technical.

WILES: I want to know where we are headed as far as these subcommittees are concerned and this workshop. After this are we going to have another workshop that approaches economics and the institutional problems? If we do, I think we are going to have to have a representation that crosses the two areas, because restating what Harry said, I've heard no real technical inhibition against resource recovery. What we find is that there's a combination of technical, social, economic inhibitions that all lump together that caused one resource recovery facility not to work, another one not to work. We are concentrating here on the technical aspects, and we are just forgetting or we are ignoring those things. If we go into these subcommittees and don't have some tie-ins to these other factors, I think we are beating a dead horse.

ALTER: Let's return to that in a moment. It's on my agenda.

LINGLE: I can throw in a vote for keeping the economic accounting issues separate. Rather than have the unit process committees develop methods of economic evaluation or accounting formats four or five different times, I think we ought to develop it once and try to follow those procedures. You might have to adapt it a little bit to different specific unit operations. I would throw in a vote for doing it all at once. With regard to what Carlton said, is the purpose of these groups to develop methods of evaluation?

ALTER: I would like to cover one thing first, and then return to that issue.

KEYES: The one thing that I can see against having the economics as a separate subcommittee is the fact that I don't think you can divorce the two as far as economic and technical problems. I would think that the people in that economics section, if you had one, would be re-doing a lot of the work that the other people are doing in order to find out exactly what type of information they wanted to gather. So it might be a duplication of effort on that part, because they are dependent on each other, they are not independent.

ALTER: There appears to be a consensus not to separate out the economics; correct me if I am wrong.

ANONYMOUS: You're wrong. I think there were two votes for and two against.

FUNK: I'd suggest this, I have under my "Other" list here to establish standards for data taking, and I've also listed as a priority Item Number 36--Develop Effective Accounting method. I think we should have a standard group that could start establishing these standards both for economics and for taking data from any performances that might be taken.

BURCKLE: I see the need both for the column and the row in the economics area. Number one, your economics framework is not going to be what I would call a measurement method. It tells you what you need in terms of data to perform an economic analysis. But in the row, you've developed the method for examining the economic aspects of each of the four areas we listed, and that feeds in to the column, if you will, of the overall economic analysis. I think both points of view are correct, if you are willing to look at it from that direction. In other words, we need a standard way of doing economic analysis, if you will, of the overall system of the plant, but we also need the measurement methodology under each of the types of unit operations we'd be dealing with.

RIGO: Harvey, it's not clear to me that we are yet in a position to talk about developing standard methods. I've got a feeling that that's probably a relatively straightforward exercise. One person can draft and get two or three people to agree that on trommel, we want to evaluate it in this manner. What we have not yet established, and what I think is the key to everything here, as Steve Lingle pointed out, we've got different data needs by different people. What intensity of data must we get, and do we need to collect data three times, can we do it once? The basic problem of what data on a particular piece of equipment you get is trivial. The general problem of what intensity of data do you get I think is critical, and is the key. That's not being addressed at all.

ALTER: That would differ with each unit operation in part, because only through experience can statements of precision and accuracy be developed. I would suggest that intensity of data is something that each subcommittee has to consider and make a recommendation. I think it would be wrong to try to solve those problems now; recognize them yes, as you did, but not try to solve them in this group at this time.

be valuable to evolving an input to their thinking. If you will first put down in which group you might like to serve then I'd like to turn the discussion into where this exercise might lead.

FUNK: I don't want to get into one of those groups, because I am interested in all of them. I want to get into a group with the rest of the A&Es and similarly related people so that we can talk about what we want out of this whole thing and what's necessary to us to perform our function. I want the Arnold Chantlands to get together and say from the guys, just like the L.A. pointed out, the designers were there for so long, and then they leave and then they are stuck with operating it. But we want to hear that from their standpoint.

ALTER: Let's separate two things, please, on your sheet. There is one, the needs as you perceive them, and there is two, of these four groups, as a method of accumulating data so different sources would be comparable. Now data on what? If, for example, the A&Es say size reduction is the highest priority, and it turns out that that's going to be investigated, then the ad hoc group might recommend data on size reduction ought to be accumulated in a particular way. There are two separate objectives here. I thought this was all discussed. The groups we are now talking about--unless there is a consensus or decision to accumulate the data, then the matrix would not be used. There are two things on your sheet. One is the ranking of the research needs and suggestions for others. The second is an expressed interest in working towards the method by which the data should be evaluated. Now on the latter, I return to the idea that even those of you who are involved in proprietary work, I do not think it excludes you from saying how the data might be accumulated, so that the data when published, even if not your own, would be more valuable to you.

BENDERSKY: Let me try a compromise. I want to suggest that if you maintain this technological list this way, it would seem to me to be well to have at least one representative from each of these major groups in each one of these so that these groups can be represented. I understand the need for groupings.

ALTER: Is this little conversation one of the things coming out, as David points out, is that in each of these groups on how the data might be accumulated, there indeed be representation of the various viewpoints. In other words, it would be a mistake to not have an A&E in the groups; it would be a mistake not to have a municipal man or systems person; and so forth.

BURCKLE: I think I see what Harvey's driving at now, talking really about two completely unrelated matters from the aspect of planning. One is developing a commonality in how we take measurements to describe system and economic performance as opposed to determining what things we would end up concentrating our research efforts on as Harvey Funk has suggested. We are not going to, of course, be able to accomplish that within the framework of this meeting at this time. I think that the methodology for making measure-

ments is being attacked by the ASTM; I know that we in EPA are supporting it. Perhaps that's really a more appropriate place to attack that sort of need. Hopefully the ASTM Committees would consider structuring themselves to include the various interests.

ALTER: As we do.

BURCKLE: Harvey Alter says they do now. Perhaps if there are those of you here that would be interested in working on those committees, this could be done, Harvey.

ALTER: We are getting ahead as to what to do now with all of these pieces of paper. One, if you are finished, I think they ought to be collected now so they don't get lost. I'm making an open suggestion now to EPA. I think a next step would be for ad hoc committees to meet to work toward evaluation methods and to reconvene this workshop to continue the discussion at some future date. To do so, the ASTM Resource Recovery Committee is a possible mechanism. The work of the ASTM subcommittees right now (for those of you who are not active and I wish you would be) has not been for methods of evaluating equipment; it has been for specifications for recovered materials and methods of tests for those materials. Almost all of the technical subcommittees have taken this upon themselves as a first priority job. I think an evaluation matrix as we're talking about now would be a leg up; you could move ahead in the field sooner. I would make the open suggestion to EPA that based on the pages that have been turned in, to decide upon and even call to order these subcommittees and invite people to participate. I would also suggest for this body to buttonhole our EPA hosts and give them your views as to when it should happen and where it might be held. I'll say right now that if there's any hesitation as to where to hold the meeting, I'll be happy to host the subcommittee meetings in our office or possibly elsewhere, provide the secretarial and typing services to get it going. I don't think that the matrix subcommittees need meet perhaps more than once. Now I'd like to exercise the prerogative of the chairman and return to a subject which Carl and Steve Lingle really raised, and that's the entire issue of are there technical obstacles or are they intertwined with the social, institutional, marketing, economic, etc. To do it, can I challenge you to say, we have a technical obstacle, maybe not well defined or articulated yet, which is preventing us today from moving ahead faster. In other words, if we could remove that obstacle, would there then be a sudden increase in the number of plants contracted for. By inference, if there are not, then as Carlton points out, we have to devote attention to the other aspects. So I challenge you: Is there a technical obstacle in our path to moving ahead further. Would the A&Es and systems designers be able to "sell more plants"? Would the municipalities be able to accept plants sooner, if this obstacle were not there?

CHANTLAND: There are many obstacles. I just point out one that I've heard others mention. You must look at the end product. I would say that you have to start at the end and work backwards. We've got to have somebody to

receive this material, somebody who's willing to pay money for the product. It was mentioned here that there are several boilers in this particular area that they can't sell the material to simply because they were designed for gas or oil, or something like this. Retrofitting these boilers would certainly open up a new area of interest to a lot more buyers. I'm sure that's perhaps true of many other things such as metals. I think this is the point that is very important, if we can't make some sales, our costs are going to be rather prohibitive.

CAMBOURELIS: Those are fundamentals, and I agree wholeheartedly. We're ignoring that, all of us.

CAPPS: I would like to make one comment concerning what's happening in California at some of the meetings I've been attending out there. The concern over air pollution is driving many people to try to guarantee meeting air control requirements. It's driving people to look for pyrolysis, and yet as far as I'm able to find out, there is no pyrolysis system that's ready for anyone to accept at the moment. So that's a technical obstacle related to a concern over a political problem in San Diego, the Bay area, and so forth.

TREZEK: I think the California problem stems more from the fact that boilers are not equipped with ash handling equipment, and therefore no boiler in California can really take RDF. So that's the problem.

RIGO: Harvey, it looks also that if we shift our focus from utilities back down to industrial scale, and if we can come up with some reasonable requirements for emission control, at least in the Mid West I'm relatively certain we are going to see a major shift from gas-fired and oil-fired industrial and small commercial scale units back over to coal and solid fuels. So if we shift our focus from the utility to the industrial scale, and we look at new construction as opposed to retrofit, there's going to be a lot of it. We suddenly open up a whole new market, one where we are going into boilers we can tailor to what we want, and one where we are going to be able to charge two or three times the fuel prices we can get from the utility. In Dayton, for example, Dayton Power and Light is willing to pay 23 cents a mega-Btu for RDF. That's all they are paying for coal. If we go to the industrial users, Delco-Moraine, for example, right now is buying emergency propane well in excess of \$5 a mega-Btu, and they can afford to do almost anything to get off of that.

LINGLE: A quick point in response to the issue of the smaller-scale industrial boilers. I guess this also partially answers the question of the extent which technical issues are compounded with other institutional type issues. Clearly, the industrial boiler market is a very interesting one for the reasons that have been presented. We took a look in a gross national sense at the magnitude of this market, and found that there are a lot of industrial boilers out there, but total national capacity is about half that of the utility boilers. That's not the concern, the concern is that the average capacity of industrial boilers is sufficient to handle about 30 tons

per day of RDF. In fact, we found that nationally there are something like 50 industrial boilers that could handle the output from a 500 ton per day plant, and that's assuming 40 percent RDF firing and 100 percent utilization. Now clearly, some people have multiple boilers and so they are going to fire the waste in two or three boilers. Also, you can market the multiple users. But, that raises the problem of financing the system, because now you've got to have contracts for the series of different industrial users. The financial community may not view this whole series of contracts as nearly as stable in terms of projected revenues as they would view the revenues from a single utility that they knew would be there for years. I'd be interested in any comments on that from the standpoint of the A&Es who are maybe looking at this market.

HOLLANDER: I'd like to make a comment, if I may. Certainly an industrial market would be an attractive one. They don't have the luxury to buy fuels that the utilities do. Consequently, they are in a somewhat weakened position. They are also the first one that's cut off when we have a fuel scarcity in one form or another. Historically the industrials do not contract for fuel for 5 or 10 years; in fact, most industrials rarely contract for fuel even for a year. They buy spot fuel ordinarily; they may have a one year contract, but we have to rely on having long-term contracts from industrials and the probability that this will ever come to pass is extremely remote. Strange as it may seem, since the energy crisis--what was it, 1973, the oil situation--the number of coal-fired industrial boilers that have been contracted for are invisible. There has been virtually no activity in new construction on coal-fired boilers. It's been very, very spotty around the country. The ABMA, the equipment manufacturers are absolutely flabbergasted; they expected to be inundated with orders. Right now they are scratching around for an order for an industrial type coal-fired unit. Now, when will it come to pass--you should be thinking of two-three-four years from now--it's not going to happen overnight. With the new FEA approach on MFBI, and I'm sure you're all familiar with that, they are going to try to at least control what kind of fuel is going to be burned in units requiring 100,000,000 Btu per hour. The industrials are going to have to justify why it's impossible for him to do anything but burn coal. It's going to take a long time before this will have any real effect. If a community decides they want to approach the industrial market, they are going to have to find more than one user, probably half a dozen users, and hope that they have such a desirable product that they will all vie for it. That happens to be why it will be difficult to get firm contracts to justify the construction of such a facility. The big attraction of the utilities is you think you've got them or can get them by the short hair and sign them up for 15 years, and this justifies building the plant.

FAY: I think the big attraction of a utility is people on a refuse processing process think they can minimize their own capital investment and throw the burden at us. No, I think that's a very key issue, because if you guys want to have a product that you get more money for, a real easy one to produce, theoretically, is oil. You can sell that any place, but you--the cities that is--are going to have to put up the front end money for a

pyrolysis or whatever it is, which I don't think is quite here today, but maybe it will be shortly. It's probably going to cost more, hopefully you'll sell your product for a higher value when you've got to trade off those things. If Milwaukee is any example, I think it is, the cities, no matter how highly motivated, are looking for somebody else to pick up the bucks. In this field, it seems to me, what held it back is that they seem to be always wanting to get some gimmick that the Federal government will throw into it for them. The real easy answer is turn out a product that you can sell more than just to the guy with a big boiler sitting there.

WISELY: In our own experience along those lines, the only industries which appear to be a really good market for this type of material are those which have a rather constant year-round plant factor. Most industries are somewhat seasonal in their steam demand. Other factor that enters into this is that an industry has got to have a financial incentive, usually, in order to use a fuel of this kind. That seems that in our own experience in a very recent project in which all the agreements between the municipality and the industry were already executed, the net (I wouldn't say profit) but the net project cost, which happens to be a negative all the way through, will be shared by the industry and the municipality. It's kind of funny here in this case where the industry because of the tax situation, feels that it really has to be a three-way split, one to the community, one to the industry, and one to Uncle Sam. All right, now, if you think in terms of the utility, some utilities of course are taking a rather different view on what they are willing to pay for fuel of this kind than others. Some of them are taking the attitude that sure, we'll do this as a good neighbor as long as this does not cost our rate payers, as long as it is not adverse to our stockholders, we'll pay what the comparable value would be in dollars per million Btus. Other industries take the attitude that well, they have to have a little more incentive than that. So I think you have to recognize that there are other incentives though, which certainly the industries and the utilities bear in mind and one of them, of course, is the matter of being a good neighbor. Others are the national image they have in the environmental, resource recovery field and that sort of thing. Although it's quite possible that you can't really allocate a dollar sign to that value, it is there, and I know darn well they recognize it.

CAMBOURELIS: I sympathize with the utilities and the pressure they are subjected to (to use RDF). I don't think they should be expected to function as eleemosynary institutions. They are there to make a profit like most private companies, like my own is. On the other hand, I think they occupy a unique position as regards to being potential refuse-derived fuel buyers almost everywhere. The central issue is that 70 to 80 percent of municipal solid waste can be extracted as refuse-derived fuel. The flow is continuous and waste cannot be stored for any significant period of time. Nor can the extracted RDF be stored for a significant period of time because of the quantity and volume of material involved. It must go to a stable consumer, if possible, one as stable as the community generating the waste. Organizationally, there's nothing, absolutely nothing as stable as the utilities

(as an RDF buyer). There just isn't any other class of organization that can consume RDF as reliably as they. However, the utility operates uniquely; they are enfranchised as a monopoly in their service area. They have to make money to provide the service because private investments are involved. The complicating factor is their fuel adjustment clauses. They are necessary, nobody argues this, certainly I don't. I think as important as all of these problems that we've talked about here is that of finding a way to make it economically attractive to the utility to buy RDF. A bargain isn't good enough, and while it's something that we should all be appalled at, we should recognize that the utility's first responsibility is stability as an energy supplier. If we could find a way to make it worth their while to use RDF in the context of the monopoly and fuel adjustment clauses that they have, and should have, we would accomplish as significant progress as solving purely technical problems. I think that the (resource recovery) technology is going to work out; I think the technology is here mostly; it's now a question of worrying it through routinely. However, we have to figure out some way to make the utilities anxious to buy RDF for self-serving financial reasons. We don't have that, and I don't know what the answer is short of the kind of tax incentives that the Federal government might enact, providing them (the utilities) with the potential to increase their profits.

ALTER: If I may sum up before we break for lunch, I think there is one message that we are left with, which is: Anything we might do to reduce the technical risk and uncertainty in people's minds even a little at a time, will move us ahead. What I don't hear from anybody is a panacea. With that we will adjourn for lunch.

SESSION 4: APPROACH TO R/D&D PROGRAMS

John Burckle, Moderator

BURCKLE: We now have in our hands a list of R&D needs, and we kind of danced around the problem of what kind of strategy to employ in conducting research and development. As I see it, we really have three or possibly four ways to go about this. We talked about a pilot plant, for example, and we talked about testing existing systems in the field. There's a possibility of testing a subsystem on a demonstration scale, large-scale subsystems. For example, say there is an existing fuel preparation system somewhere in the United States and we want to find out how a particular pyrolysis unit will work. We could have the ability to fund the construction of a pyrolysis unit in proximity to that fuel processing system so that we don't have to completely build a total system just to test the pyrolysis. We also have the mechanism of the full-scale demo, where the system is actually integrated into the community's solid waste management system. These various strategies give us different types of qualities of levels of information, and I think that we talked about pilot plant testing and the problems there. We talked about field testing and the problems there to an extent. I'd like to open this area up to the panel to explore in more detail

the areas of pilot plant or field testing versus demonstration either of the subsystem or the complete system, and welcome questions at this point or comments. I think one thing we ought to pay particular attention to is scaling in our discussion here. I think that strongly influences the approach to conducting research and development, and I ask the people in the area that furnish technology or technological systems to consider their experience both with their own plant design efforts and utilizing EPA data and the data of others. What kind of problems did they have with scaling? How believable was the data generated in government-sponsored work? How useful was it to you when one considers the factors of scale? What kind of impact does data from a full-scale demonstration project have relative to pilot plant work? What is a reasonable scale at which to perform R&D for, say, a large municipal system, or an intermediate size municipal system? What unit processes is it felt can be adequately scaled with the existing information or techniques? What unit operations are essentially impossible to scale based on today's technology?

LALKA: On the Monsanto project you sponsored, we went all the way up to a 1,000 ton a day plant from a small pilot plant unit, and I think that that stuff's a tremendously large scale-up from a pilot plant to a 1,000 ton a day plant. A 1,000 ton a day plant would probably handle a population of, say, 400,000 people. I think it would be more reasonable to attempt to scale up to something somewhat less than a 1,000 tons a day. In fact Union Carbide, for example, has now gone to the modular concept, where they are talking 350 ton modules, something like that, and that way you might be able to develop a system that would serve a small community as well as a large municipality. I think your effort would be better spent in that direction. This problem of scale-up is really tremendous, and any data that you would get from a larger plant, I'm pretty sure it would not be applicable to any other type of pyrolysis system. You'd be developing data for just one system. None of them are exactly the same. So overall, I'm not sure how useful this information would be with regard to pyrolysis. It would be just maybe a statement of one system, not really any other type of unit.

HOLLANDER: I agree.

PARKER: I have a problem. I'm up to my hips in 700 tons of data every day, and my problem is sampling it. I think that the question of data extraction is diametrically opposed to pilot plant and demonstration, small demonstration plants. If you have a small pilot plant, you can stop and start the conveyor as often as you want. You can clean the conveyor, you can divert the waste here and there. When you build a plant for profit, like Recovery 1 is, that's exactly what you have to do, make a profit. And when you start getting in and sampling, it wasn't designed to do that, it was intended and designed to process waste. When you perturb that by trying to take data samples, you run into difficulties with running the plant. Now the problem I have is, how often do you sample, how large a sample do you take, where do you take it, and how do you take it without perturbing the plant process. I've been wrestling with this for several months now, and I haven't come up

with any answers. I don't know of any place that there's a book that says a 250 pound sample of ferrous material is adequate to sample the ferrous recovery system. A 250 pound sample on the tipping floor is adequate. I throw 250 pounds out, because that's the number I found, but I don't have any confidence in it. I'd like to know what other people have found in regards to sampling process flow and efficiencies on plants of this size. Harvey has the luxury of [unintelligible] where I don't. That's why I say that there's an opposition here, where the best data comes from the big plants, because the sample size is larger, but that data is harder to get than in the pilot plants where you can stop and start it. So you have to compromise somewhere, it would seem to me. I think it is going to be very expensive to get the data from a large operating plant because you are not going to be able to do it when the plant's on-line. You are going to find yourself working on the third shift, you're going to pay the operator at the plant extra to have the shredder operator there, and to have the Man-power, Inc. people come out with rakes and the sorting tools for you. Data obtainment on the big operating plants is going to be a very expensive proposition. I just hope it's going to be worth it when we get it done.

HOLLANDER: We have here today a gentleman from Wisconsin Electric and also from the City of Chicago. On the one hand we have a producer, and on the other hand we have a consumer or user. The user is concerned with what he's going to be buying, what is it that he's paying for. Similarly the producer is going to be providing something to his customer. How do you propose to monitor the value, the quality, how do you intend to sample, do you intend to sample? Tell us what your approach is to this very problem that was just raised.

FAY: We are very concerned about this because we are paying for Btus and Mr. Sjoberg thinks 80 cents a million is too low, but nevertheless that's about the going price. We're very concerned about getting a representative sample, but nobody knows what that is, including the ASTM committees who are trying to say what that is. We are going to do a lot of sampling initially. We have our own analysis lab that we analyze all our coal in, and hopefully over a year's period of time, American Can and Wisconsin Electric will arrive at some sort of variation agreement, and determine from that point do we really have to sample every other truck, or can we do it once a day or twice a week or whatever. What we did not do two years ago when we agreed on a contract, was try to determine all of these things without any operating experience. We built into our contract a one year program to do lots of testing, including sampling and analysis, and then we are going to have to sit down and agree on what we have. That's the way we are approaching the subject. We don't think the answers are here today. The man on this in my shop has been to Ames, he's talked with as many people as he can talk to. We think Ames is a different ballgame than ours because (and I may be stating it incorrectly) I guess what they lose on one side they make up on the other, what have you, it's all the municipality. That's not the case when you have a utility like ours buying fuel.

BURCKLE: Is that on a dry basis, 80 cents per million?

FAY: As received, same way we analyze coal.

BURCKLE: As received, the same way you analyze coal.

CHISAMORE: We are working currently with Ontario Hydro in the design stage of a plant similar to what Bud has described, and we hope to get some of the answers from what we call our experimental plant. It is about a 300 ton a day plant, and it is being designed in such a way that we can shut it down at will, because no municipality is depending on it. The transfer station will start up next month and the processing part of it in June. Certainly the agreement with Ontario Hydro and the municipality is such that they are paying for Btus. We wrote in the agreement the same thing, it's the equivalent of Btus, but the problem of how you come to an agreement on how many Btus we deliver has not been resolved yet.

PARKER: I was misunderstood. I'm not concerned with sampling the end product. I'm referring to the discussion we had this morning about sampling unit processes or systems. How do you determine how efficient your aluminum recovery system is, how do you determine how efficient your ferrous recovery system is, without stopping the plant?

BURCKLE: Bill, do you see a need in your plant operation to do some of this kind of sampling on a periodic basis to check out how the equipment is operating, to find out perhaps if maintenance is required in certain unit operation?

PARKER: Yes, there's that need, but there's also an obligation we have to test the plant. I'm concerned with that right now. I'm concerned with data gathering just to see how well the plant will function and to make it function better. This is a 12-year plant, now down the line and not too far down the line, we're going to have to draw up maintenance manuals, as you referred to, we're going to have to determine what is the minimum performance that the drum magnet will operate at before we have to start to think about changing it or readjusting the air gap, or changing the belt speed or something. Those are corridors within which you will normally want to operate the plant. Before that you want to find out how well it's going to operate and how well it can operate. Then you set the limits of acceptable performance. The problem I have is testing it to get those limits of acceptable performance, and at the same time doing some R&D. What happens when you speed the trommel up? What happens when you change the air gap on the aluminum magnet? Or when you change the reagent in the froth flowcells? All those things are easy to say you are going to do them. They are more difficult to do in a plant that runs 700 tons a day.

HOLLANDER: Burckle, there should be someone here from Americology. They intend monitoring the effectiveness of their line, and he addressed that question. Is he here?

SJOBERG: We are currently in the process of shaking down the plant and have built into plant operations the subject relative to evaluation. I think one

thing you have to evaluate is the time frame over which you are going to gather your data, because of the inconsistencies in the stream that you are dealing with, plus the seasonal and cyclic effects that you are going to have. I don't think any batch sampling is really going to give you any information.

PARKER: I think you are right.

SJOBERG: I think what you have to do is establish your evaluation program over some reasonable time frames, which goes along with what you presume the cyclic effects are going to be. During that period of time you not only evaluate your efficiency, which we will be doing on a weight basis, but then at the same time set up a system of bookkeeping within the plant to evaluate your maintenance downtime relative to performance downtime, relative to maintenance costs--normal, relative to emergency maintenance. All of these types of things are being built into our accounting system, if you will, or plant operations system, so that not within the first month can we presume to tell you how the plant is operating, but within at least the first six months. I don't think any batch system is going to prove anything.

PARKER: I agree. The accounting manual is a vital ingredient in determining the operating effectiveness of the plant. We are building an accounting manual now that the company that runs the plant and owns it will use to report their expenses and expenditures on. Beyond that there's the academic interest of data, and the accounting manual comes in there because we have designed it so that we can pull that sort of information out. There are other things the accounting manual isn't going to take into account (that's not intended to be a pun); there are some things it won't see. It won't see when the aluminum magnet becomes less efficient. It won't see when the glass isn't as pure as it ought to be. That's another whole ballgame. How do you test 50 tons of glass that we're going to generate in one day to see if it passes the GPI spec on glass, without getting rid of the whole batch of glass? Turnaround time is like two days on a test sample.

BURCKLE: Could you all perhaps speak to the difference on the sampling; you mentioned batch sampling not being satisfactory. What is the alternative to batch sample?

SJOBERG: If I read his initial statement correctly, or heard it correctly, it was a function of shutting down the plant and operating it for specifically short periods of time to evaluate performance, and to me that's batch sampling, which is not going to be of any value to you. I think that relative to the performance of the plant you have to then differentiate what you mean you are trying to establish the performance of. We go to the plant overall and you break into the cost centers and things of that nature; you end up with a performance based upon manpower allotted or working at a specific station of the plant. Downtime. Why the downtime? This gives you an equipment performance trail that you can follow. We are going to obviously sell the material from the plant. Consequently our sampling relative

to the products we put out the back door of the plant are going to have to be an on-going, everyday situation of which we are in the process of developing specific techniques required to evaluate that product as if it came out of any other manufacturing plant on a QC basis. We will have to know every day exactly what the quality of the aluminum is, the quality of the glass, the quality of the material we send to Mr. Fay, the quality of the steel, because our revenue is dependent upon that quality.

RIGO: In trying to take apart the Landgard plant, our design calls for not biting back inside the process too far but simply getting our hands on all of the outfall data. Now what does this tell us on the plant? We will be able to walk from the outfalls back into the process, hopefully, to some extent. For your problem of determining when you are getting a quality change, what you can do is, when the plant is running properly, establish relationships, for example, on percent aluminum contamination in your magnetics versus some other point in your outfall. You'll be able to get some kind of relationship, and when this relationship changes, you'll know that something has gone wrong. You might be able to use that as a warning or detection system.

PARKER: I have trouble backing into the plant from one of the outfall points, because you don't go very far before you come to a common point.

RIGO: That's right.

PARKER: The cyclone collects the organics from the ferrous concentrator, and from the air classifier. Which part goes where?

RIGO: That's a separate problem; that is a research problem.

PARKER: But it's a typical problem.

RIGO: Right, but your problem or your second problem, of maintaining quality control I think you might be able to address by monitoring all of your outfalls and establishing some relationships for proper operation, and establishing what the relationships look like under certain types of upsets. You then know when a relationship changes, you've got a problem, and you might be able to detect it before you have catastrophic failure--like you can't sell your product.

PARKER: The product quality is one of my concerns. The way the plant operates and how well it operates is the concern I have right now. Before we make a pound of iron, I'd like to be able to say how well the ferrous recovery system is supposed to work, and what makes it work good or bad.

BURCKLE: To get us back on the track here a little bit, I would like to pose a question to the workshop. I think the basic question before us is in terms of generating data. At what scale does data from the research effort become believable to the community that will use this data for their

plant design? Are there advantages in not trying to go the pilot plant route but just simply field testing? For example, say the Americology people were kind enough to let us come in and test their system out. Is this sort of thing possible? How does the community look upon this kind of testing? We have the option of a subsystem demonstration or a complete full-scale demonstration such as San Diego, Baltimore, or St. Louis in terms of trying to generate data for the general community use. I'm really interested in trying to get your opinions and feelings as to what approach is perhaps more appropriate for generating data for your use and particularly the concept of the scale in which research should be done or carried to before you feel it's usable to you.

LINGLE: I was just going to suggest, John, that again I think you have to put the end use of this information into the equation of at what scale of operation do we want to collect data. You have to also decide, are you doing this to try to prove or disprove performance of a system or are you doing it to try to develop design information on a component? I think that the scale of operation at which you are going to carry out your testing is going to be different depending on which one of those objectives you have. So again, I don't think there is a single answer; I think it depends on your objective.

WALTER: I'll agree, and I'll give you the military answer, which says it depends upon the situation, depends upon what specifically you are trying to do. Any given research program has to start from a basis and to work itself in an orderly manner through the entire spectrum until you finally hit the big crunch, which is called full-scale demonstration to see if it will really work--potentially Seattle, or Saugus, or Nashville, or what have you. There is no given answer. You may be very willing, because of other data that you know, to scale up a thousand times. There may be other times when doubling the size of the thing may be too far to go. There's just no answer. You have to look at each situation and analyze each one; there's no way to do it in general terms. I get a feeling when you are talking about this sort of equipment from what I've heard here in the last day and a half, that it's a particularly difficult answer, since everyone seems to believe that there is no way to predict scale-up figures for plants. If you build a bench model then you might as well forget you have built it, except you proved what's going to happen with that size and whatever you put in it. You go out and build a full-scale and operate and tinker with it. The only real problem I have is that it seems to me that what people have been saying in general is that the operator, if you will, is the tinkerer. I had a lot of experience in building maintenance, and as a building maintenance person I was a tinkerer. My only real problem was, there was never a flowback of information to the designer or the builder of the piece of equipment, for him to know how I tinkered to make that thing work. Therefore his next one looked like his first one, and the next guy started to tinker with it too, until I bought the second one. Then I told them, make this work, I want you to change it this way. There's got to be a better backflow of information and I have no magic solution on how that occurs.

HOLLANDER: There's another aspect. If you were an equipment supplier, you would be concerned with how many units you can sell in a year. You would address what the size of the market is and what the size of the components would be that would give you the greatest potential in this area. If you were a systems builder, like Monsanto attempted to be—they determine the single most economic size for them that would be attractive to the marketplace. The idea that was expressed earlier from our friend from California, of a plant made up of one or more modules of intermediate size, would provide the manufacturer of the various components and the hardware with the greatest flexibility for replication. We have to recognize somebody has to fabricate this equipment, and what drives them, and what are the incentives. So when we talk about scale-up, are we talking about scale-up from a bench, are we talking about scale-up to commercial size, what is commercial size? Is a single module, a single line of equipment a commercial size? When you address that problem, then you have another perspective as to what you are addressing.

RYDER: I have a slightly different viewpoint, I hope, from a real world approach. I always thought that when a new idea came out and before millions of dollars were invested, a pilot plant was built to see if the idea was sound. After the pilot plant was built, conclusions were drawn as to what was needed for the full-scale model and then the money was spent. Therefore, after people spend millions of dollars and essentially use the large plants as oversize pilot plants knowing that the idea is basically sound, why go back and build a small-scale model to see if we did it right?

WARE: It's easier to work with pilot plants.

SPENCER: If I could add to that, I think that it's so that the next time that you build a big one, you do it better.

RYDER: We'll know that when our present plant gets on-line, and we get operating experience. It's much more reliable to judge from the real thing than from a small-scale model under laboratory conditions. We've got the big one right here. A year from now we'll know many things that we could never learn from a small-scale model in the lab.

SPENCER: You might be able to identify how that big one works, but you may not be able to identify what to do to make it all work better.

RYDER: If we didn't we would be remiss in our duty. We wouldn't just run the plant without making some kind of evaluation as to how it's working before we built another one.

BURCKLE: I think what Dave was getting at is what if you were to use a different sequencing of unit operations, or insert a new unit operation, for example. I don't know whether you are intending to use pre-trommeling or not, but suppose you were not, and the question came up, could I produce

the same quality fuel for less cost if I use a different type of process? Pre-trommeling is an example. I think that's the point Mr. Spencer was getting at. Surely we would know in testing an existing system over the band in which we conducted our test, how we could tune that system to operate at its optimum performance, or if there was a part of it that didn't perform its job properly, what kind of fix to utilize so that that particular design could be changed on the next iteration.

RYDER: We will be doing that in the next year and the next two years, and probably as long as the plant is operating. We will be trying different approaches all the time to improve the efficiency of the plant.

CHISAMORE: It seems to me that the scale-up features are not unique to this industry. The pulp and paper industry has done this in terms of oxygen bleaching, for example. They simply went from small-scale to the full-scale working plant and obviously having committed a major investment to it, having to make it work. We may be in the same position.

LALKA: I think the chemical processing industry, the pulp industry, they are dealing with one particular feed material. We're dealing with a type of feed material that changes every single day. It varies all over the place. It's tremendously difficult to handle. It's like no other industry. For that reason, I think the small-scale pilot plants cannot be easily scaled up to large units. On the pilot plant level people are running, say, one load of waste. That's fine, one load of waste doesn't in any way represent what you'll see over the life of that plant. So much of the data developed is meaningless, and we've seen all of the problems in the past that have occurred in this attempt to scale up refuse plants. It's very easy to work with these things in your backyard, but when you go all the way for the big time it doesn't seem to work that easy.

RYDER: I might add a little more to what I said. We are already doing that. For example, we are already looking at improving our magnetic separation system. Because our system was designed three to four years ago, we find new ideas have developed since then - such as an improved magnetic separation system. And we'll look at other things such as the trommel or whatever else appears in the next few years. We're not sitting still in other words, we have an on-going laboratory within limits as long as our capability to dispose of refuse is not jeopardized.

BURCKLE: Any other comments on the point of scalability or research approach?

SPENCER: I'd be a little skeptical of, for example, shredding information, where the shredder was at a capacity much below 30 to 50 tons per hour in terms of our problems. I'm sure other people have different problems, and would be happy to look at information on a smaller system like the one you are looking at, George. I think there is some data you've developed there, but I think there is other data that you can't develop because you are talking about much smaller units of a different design than what you are en-

countered with when you get to larger systems. Certainly in air classification, I'd think, it would also have to be up around that capacity--30 to 50 tons per hour. I think the same on magnetic separation. I would think that when you got into glass recovery that you could probably in a test facility split down to a much smaller size, because your material is more homogeneous, that's not to say it doesn't vary from day to day, but I would think that from a large bin you wouldn't have to process all of the material. You could split it out and have a continuous operation taking some percentage of the total glass produced at a 50 ton per hour rate and just be [unintelligible] and how big the sample is. How much can you afford to test? Once you've made glass, at least by froth flotation, you sure can't hand pick it. The real problem there is, of course, the nonfusible materials. That test can only be done on one pound samples, even though it might be a split out of a 50 pound sample. Then you still come up with the question of how do you take a 50 pound sample out of a 20 ton or 100 ton railcar. Do you take off a very small feed stream continuously, or do you take every so many minutes a sample out of a continuous feed stream, or do you dig your shovel into the top of the car? I don't think there are any real answers to that, except as that testing method shows up in your marketing agreements. I think that the glass industry's probably pushing that in one particular direction more so than a systems supplier. In any event I think that there are some operations that could be tested at much less than 500 tons a day, or whatever you want to talk about, and there's some that anything that was less than that I wouldn't trust, especially where the material is very random and variable, like at the beginning of the feed stream. After you've made those classifications of magnetic separations and screenings, I guess I would trust data that was substantially less than 500 tons a day.

HOLLANDER: Are you saying that there is a minimum size plant, too?

SPENCER: No, I'm only saying that in my particular design problem, which might be different than a lot of others, if I see a lot of data on some of the earlier stages, certainly on our air classifier we were testing it, I'm not making a pitch for it, but we didn't believe our own data and wouldn't really believe it until we tested it full scale. I'm sure Americology feels that way, and Garrett does, even when you do it at small scale you don't really believe that you can do it full scale until you do it.

HOLLANDER: Mr. Burckle, earlier I mentioned a commercial size plant that should be tested. What is the smallest commercial size plant that is practical? It may be that you might have to put in a 40 ton per hour shredder even for the smallest size plant that would have half that capacity. We might use as an illustration the experience at Ames. Arnold, would you put in less robust equipment than you have now, if you knew that all you would have to contend with was half the flow rate through that plant than what it was designed for and what it's really capable of?

CHANTLAND: I would have to say that I believe I would not, particularly as most of this equipment is subject to severe abuse by the material that is

being fed into it and it's being asked to receive. If you know our system, we do very little at the front end, and unless you can guarantee some sort of front end separation that's going to pull out objectionable things which we talked about before, it gets very difficult to, you might say, scale down.

HOLLANDER: So if we are going to have any kind of test program, it has to be at least on equipment of the size such as you have at Ames.

CHANTLAND: I think so.

HOLLANDER: It has to be an on-going program monitored over a long period of time so that the peaks and the valleys and unusual things will show up, so you can be aware of the limitations and constraints of the system.

CHANTLAND: Yes, only I have to support very heartily Mr. Lamb on the testing of units within a process. The pilot plant, as I see it, is a totally new system you want to subject to evaluation; whereas, if we are simply looking at problems and what we are facing today, it seems to me that we'd better back off and test the various units available. We might find out that even a plant that is now built or one that's in the design stage has an option to move into these other units, because they do a little better job or some other criteria. Just remember, I'm involved in problem solving, I'm not a deep researcher. There are problems and I'd like to find solutions.

BURCKLE: Arnold, I'd like to ask you, when you say you'd like to see more information developed through testing on alternate units. In what framework do you see these tests being done? At existing production plants? Or do you see a large scale test facility dedicated to this sort of thing, or just how would you see this being accomplished?

CHANTLAND: I think it could be in either case, if you get back to what we were saying this morning. We've got to establish some parameters, some ranges that you are going to go with in testing any particular unit. Everybody talking about the same ballgame in testing. I can see it in either existing plants and existing facilities, special research facilities, or any way you can get the job done. The important thing, I think, is to get the job done.

BENDERSKY: We've been looking at some of the test data that's been recorded primarily on a research basis. We haven't found good data which shows a systematic approach to determining the question of what equipment is scalable and what isn't. Until that is done, we know from some hard experience on Baltimore and other places that certain things appear not to be scalable. We really do not have systematic data that answer the question: How small can you test a piece of equipment and use the data on a larger piece of equipment? Until we have that kind of data, it seems to me we have to take the cautious approach and test at full scale where we possibly can, so the data is more meaningful.

ALTER: Yes, David, but, and I think that we can learn from the minerals processing industries. Some of our equipment scales from there. The outstanding examples are screens and froth float cells. I include in screens, with fingers crossed, trommels. The trommel we'll see tomorrow was scaled from pilot tests using the scaling laws for trommels.

BURCKLE: Are there any more comments on this particular subject?

TREZEK: Just to answer these other, I think the pilot scale gives you some feeling for what it is you're supposed to measure in the first place. I think it's a very important thing to get your head screwed on right before you go out in a big plant. Secondly, it gives you the flexibility of easily changing things around and trying new ideas, and things like that which you can't do. I think that's the real value of the pilot thing.

SPENCER: You'd have to agree also that the job's not done when you've finished with the small scale but you then have to go to the next step.

RIGO: Hopefully the pilot scale gives you enough data that the larger unit is a validation problem instead of redoing everything, where your cost has also scaled up.

BURCKLE: If there are no more comments on this section, I think we will move along. We have several other people who are involved with pilot plant operations. I've asked them to give a brief 10 minute summary of their pilot plant capabilities, the type of work that is being done at these pilot plants. I'll turn that over to Dr. Alter for his presentation at this point.

ALTER: We started out five years ago to get a few numbers and relieve the technical uncertainty I spoke about so much. What we found in working on the trucks and by air shipping refuse here and there, and then moving equipment hither and yon, was that it is very expensive to ship garbage to the equipment or equipment to the garbage. Thus, there is a need for a pilot facility. Then we got lucky and found that in the District of Columbia, in the incinerator, there was an unused OBW facility. We signed a no cost lease with the District, where they provide the facility and we provide the maintenance and pay for the power. We moved in a few years ago and the pilot plant has grown like Topsy. The majority of the process flow is shown in the upper part of the slide. The waste is received on the floor, pushed with a front end loader into a conveyor pit, and up to the existing shredder, which is a Williams 780, 1,000 horsepower, vastly oversized for this purpose. However, the conveyor is undersized; it was sized for OBW and that sort of limits us using MSW. At the present time, the shredded refuse discharge goes to a Triple/S air classifier, one which was the prototype for Chicago and New Orleans. It is loaned to us by Triple/S and we have been working with them. This is one of a number of instances where we have been able to borrow equipment rather than having to buy it. For example, the heavy fraction goes past an Eriez belt magnet loaned by Eriez, to a con-

veyor, by a magnetic head pulley, and then through a trommel with 2-inch and 4-inch holes. The minus 2 goes to a glass recovery module, which I'll show you. The plus 4 goes into a chute as reject, as a waste, and the 4 x 2 middling goes through a CPC Almag eddy current separator. The Al Mag product is collected on the side, and then it has to be cleaned, which I will also show you. The Al Mag system was purchased from CPC by Alcoa and loaned to us. The air classifier light fraction goes through a blower and is de-entrained in a cyclone, through the rotary valve and is pneumatically conveyed, either to the incinerator pit, where it is disposed of for us by the City, or it goes to the d-RDF module, which I'll also show. The District's incinerator is a 1,000 ton a day, no heat recovery, and clean. The nice thing for us is their cooperation that we can get the refuse and they can dispose of unrecovered or recovered fraction. We do not sell anything from this plant. We're willing to share samples for investigative purposes and when possible, share the resultant data. This is the receiving area, originally installed for OBW. Within the plant is the ability to move equipment in and out and try this and that. Here you see commercial waste on the in-feed conveyor belt. I point out the hood that is built over the belt. It was mentioned yesterday that shredders "blow-back," and this one is no exception. We tried venting the shredder, and it didn't work, so we solved the problem of the blowback by hooding the input conveyor, and it just blows back on the input conveyor and keeps coming back in through the shredder. It is a rather inexpensive solution and I wonder about its broad applicability. This view, for those who haven't seen one, is of the Triple/S air classifier. The new air classifier to be installed in the spring, will go outside, and this one will be replaced by a vibratory feeder Triple/S is lending us. We will feed the air classifier that way.

WISELY: [Unintelligible] comment on its performance?

ALTER: Well, this gets to what I tried to raise yesterday. What is the objective of air classifying in a particular location? If it is to maximize a yield of fuel, then this air classifier is fine. If it is to maximize the quality of the fuel, no. Related, if it is to maximize, say, aluminum recovery, questionable. You have to define such objectives and have leeway in changing the operation and adjusting the device. Performance for each objective is not easy to measure. The diagonal conveyor in the background carries the heavy fraction. The primary magnet can not be seen in the shadow. This view shows the trommel feeding the eddy current separator. This arrangement has since been changed and no longer goes to chute, but to a conveyor. The minus 2 goes to the glass plant, the middling, the 2 x 4, to the eddy current separator and the plus 4 to a waste conveyor on the other side. The Al Mag product comes out here, and on the other side, bilaterally, and on the left is the 4 x 2 Al Mag reject. The Al Mag product contains aluminum cans, foil, some dicast, occasionally a piece of red metal, and quite a bit of organic material which gets swept off the belt or otherwise clings to the metal. In order for the product to meet any sort of reasonable specification, it needs a cleanup.

LALKA: Is this Al Mag a commercial size unit?

ALTER: Yes.

LALKA: What other pieces in your installation are commercial size?

ALTER: The Triple/S air classifier. By loading up the belt, we've put through much more than 20 tons an hour, but we've run it at 20-25 tons an hour. The belt magnet, the head pulley (the magnetic head pulley), the entire Al Mag system are commercial size with one possible exception. This trommel may be undersized, but it was sized as a compromise to fit into the space. A difficulty that we have, a constraint, is space. We have to fit into the building and the building wasn't designed for this purpose. As I show you the other modules, I'll point out scale. The shredder is vastly oversized, as I said; that was part of the existing installation. Just to give you an idea, we now have conveyors going hither and yon in order to carry off the waste fraction. This again is a function of having to be put into an existing building. To clean the Al Mag product I referred to, to separate diecast alloy from the can stock and organic contaminants, we have been playing with what I call a "breadboard prototype air knife," which you see in this slide. It has a vertical zig-zag air classifier, followed by a vacuum hood. The diagonal pipes are to blow off the cans and foils from the diecast. I don't know the answers yet, but certainly at a rate of maybe, real pilot scale, say 100 pounds an hour, we have been able to produce what is commonly referred to as Alcoa Grade 1, is the can stock grade scrap. I should also say, before Arnold Chantland asks me the question, we have also played with the Ames aluminum product here, and the answers are different. The Ames Al Mag product is much different in character from ours. Here's a possible effect of city-to-city differences. The brochure from Harvey Funk says Ames waste contains 0.3 percent aluminum. The Bureau of Mines found more than 1 percent aluminum in Washington. The result is we see less wood, less diecast, more cans, more foil, more paper in the Washington product than Ames. I think the settings--the manner of operation--of this device may be suitable for one city and not the other. To the glass. Under the trommel at the present time there is a screen. The minus half-inch is fed from this screen to a conveyor, from the conveyor to a jig. We are using a Bendilari jig we bought from the baryte mines of Utah. We believe the jig to be oversize in full commercial scale. From the jig the glass product is chuted to a Penn Crusher impact mill. Again this is a commercial piece of equipment, and if this one should be small for a full-size plant, the manufacturer knows how to scale up. The material is crushed to minus 20 mesh, and slurry pumped to the other end of the building, where we had more room, to the froth float cells. We have used Denver cells, again, full-scale equipment or easily scalable. At the present time, there is a dispersion float followed by a rougher, two float stages and one scavenger. At least, that's the way it is piped now. The product goes to a spiral classifier, the gangue is slurry-pumped back to the other end of the building, to a Henry settling tank, which was originally part of a wet dust collecting system. This is a close-up of the four cells. The spiral

classifier, for those of you who haven't seen one, is shown here. The dryer, which is not completely installed yet, is shown here. It is a rotary type, oil-fired. You see there is much in here that doesn't need research, such as a spiral classifier. But I think things like the froth cells themselves need research. Equipment from other technologies must still be installed, shaken-down and maintained. Its performance on this new feedstock--from MSW--must be determined. To those of you who have never seen froth float glass, this is feedstock. On the scale on the bottom of the slide, each mark is one millimeter. You can see the little black specs and other fine materials, and a piece of brick, etc., that are mixed in with the glass. When this material is floated, as you might expect, you see more glass, even a piece of opal and you usually see a piece of blue. It is clean glass, which shows why the interest in the froth float techniques. Moving to the light fraction, we de-entrain the light fraction and pneumatically convey it to another room. What is not shown in this little drawing is that there is a cyclone feeding the screen on the left. It is a vibrating screen, probably undersized, but it had two other good attributes. One, it fit, and two, we owned it. That screen may stay as a feeder because with our new air classifier, we are going to screen before air classifying, thus hoping to increase the glass yield and reduce the ash in the light fraction. The light fraction is fed into a Heil secondary shredder, which I will show you in a moment (it has been modified considerably for the light fraction), then into a live bottom surge feeder to a California pellet mill densifier. This is the outside, where the light fraction comes out of the air classifier. At this meeting we have talked about materials handling problems, such as bridging. This cyclone illustrates some of these problems. That cyclone was sized working with one of the large cyclone manufacturers. After analysis, we bought one the next size larger and yet it is woefully too small for the capacity. I question if anyone knows how to size a cyclone in this business yet. You notice a spinout on the bottom of the cyclone of an odd shape. We found the light fraction bridging at the bottom of the cyclone. So we rebuilt it with 2 x 4s and plastic film, and found a configuration that didn't bridge and duplicated it in metal. Since then it doesn't hang up. Why that particular configuration and whether another one would be just as good, I don't know, which emphasizes why there must be research in materials handling. The duct work conveys the light fraction to the pit, or alternatively into the d-RDF room. We have not yet seen wear in this chute. This view is of the d-RDF room; the Heil-Tollemache shredder is in the background, the CPM in the foreground. I'll show both in closeup. Again, quarters are cramped because of the space limitations. We also found that the Heil moves a lot of air, and it really blew the product through cracks in the covered conveyors. We have since added a hood and a vent and exhaust to remove some air, and recirculate the dust. We tried a number of hammer arrays in the Heil in an attempt to reduce the size of pieces of textile. We did not know what particle size we needed to put through the densifier, but we found, more importantly, that the textiles hung up in the densifier and caused jamming. The result was not hammers, but rotors and stators. If this device continues to work well, I will start to call it a light fraction shredder. It is certainly not a hammermill. There are a

few hammers in the bottom as sweepers. The material is shredded to minus 3/4 of an inch, so the textiles are fairly well macerated. We still get some accumulation of textiles on the bottom machine.

SPENCER: [Unintelligible question].

ALTER: These are free-swinging.

ANONYMOUS: [Unintelligible question].

ALTER: We are screening to attempt to take out some of the inorganic fines. Apparently we do, judging from the ash measurements. This is looking at the densifier. For those of you who haven't seen it, it's a 33-inch die with one-half inch holes. We are presently making pellets one-half inch diameter by nominal one inch long. There is a breaker bar to control the length. In this closeup, you can see the pellets extruded through the die. The d-RDF in this hopper weighs about a thousand pounds.

CAMBOURELIS: Harvey, do you have any idea of how much that unit operation would cost in a production situation?

ALTER: No. It depends very much on the operating availability of the equipment. We are going through that now, and don't yet know.

CAMBOURELIS: Can you estimate it?

ALTER: Not ready to. In the end we certainly shall.

ANONYMOUS: What's the horsepower?

ALTER: One hundred fifty. You are now looking at about 9 tons of d-RDF pellets. We ship them in roll-off containers, each container about 9 tons of pellets. We are presently shipping the pellets to a power plant and Greg Rigo, under EPA contract, is burning them. The way we have had to put together the plant, there is a surprisingly large amount of demand maintenance. Also, it is not always a clean operation. I'll also tell you that we've consistently underestimated the amount of time and money it takes to do research in this plant. There are always surprises here. If you want to do R&D, our experience is, have a large bank account. Also plan on more people than you figure. We use engineers, mechanics, co-ops are very good form of labor, and day-laborers. Thank you.

BURCKLE: The next one I have slides available on is the Bureau of Mines, Roger De Cesare.

DE CESARE: The majority of you are familiar with the Bureau of Mines history, but for those of you who aren't, briefly, let me say that when the Solid Waste Act was passed in 1965, the Bureau was asked to evaluate the potential of recovering minerals from refuse. They recognized that the easiest way to concentrate the minerals from the fraction of municipal waste

was to burn off the organic fraction; therefore, early research centered on municipal incineration residue. Residue was in many ways as rich as many ores being mined today, and it proved to be amenable to conventional mineral dressing techniques. We set up a pilot plant which has been operating since 1969, using conventional off-the-shelf equipment, and developed a system for recovering the minerals from incinerator residue. Separations are achieved in a relatively simple manner, and projected economics for large scale operations are very attractive. With the reduction in number of municipal incinerators in the country, the Bureau realized that residue recovery would not solve the solid waste problem in the majority of the cities. We then set out on a program to develop methods of separating various fractions contained in raw municipal wastes. We also centered on the problems of the East coast--large cities who are running out of landfill space. Unlike incinerator residue, raw refuse could not be treated as normal ore, and is not amenable to conventional mineral dressing machinery. Even though the machinery we found to do the job was from agricultural and construction industries and not the minerals industry, the approach taken to separate the refuse was the mineral dresser's technique. In other words, we recover the minerals in as large a particle as possible, separate into fractions which can be further processed as needed. We arbitrarily decided to pick material larger than two foot in size, and to process materials two foot or smaller. The first thing we felt was needed to be done was break open bags of refuse and to liberate all the material within. We found the flail mill to do this job very economically. It would take everything that we would feed it, and while it did not shred any massive items, at least the massive pieces caused no damage to the shredder. As I mentioned yesterday, we found that the flail mill required an exhaust hood, so we utilized this exhaust hood as an air classifier to remove about 25 percent of the light paper and plastic fraction. This fraction was a relatively clean fraction, because it was separated before it was mixed too thoroughly with the rest of the refuse. Since no separation process is 100 percent efficient, we decided to use a series of air classifiers rather than a single air classification stage. We did purchase and test a few air classifiers which were used in the agricultural industry, but were not able to apply them to our needs. Thus we were forced to develop our own classifiers for our plant. I'll now show you some slides of our equipment. I'll show you a few pieces of equipment from the incinerator residue plant; I don't intend to dwell on it. Our process for incinerator residue is a wet process. We have washing and screening and shredding operations. Here is the first screening step, washing of the ash from the incinerator residue. We then go to shredders, more washing and screening, and then to magnetic separation. The non-magnetics are then further crushed, and this crushing operation breaks the glass up to minus quarter inch in size, and a vibrating screen concentrates the nonferrous metals. If you have a good burn out on the incinerator residue, the non-ferrous metal product from this screen is better than 95 percent metal. Heavy media or jigging can be used to separate the aluminum from the copper/brass. The rest of the operations deal with the minus quarter inch. That's more crushing and washing steps. It gets rather tedious to try to explain in a short period of time, but it's a similar type of equipment,

and I don't think I'll go any further into it at this point. In the raw refuse pilot this is the flail mill we were talking about. We bought this unit back in about 1970. It cost about \$13,000. It will handle a lot more than we can put through it. We've never been able to test the full capacity. I'm sure it will handle 10-15 tons per hour. The rest of the machinery is scaled at 5 tons an hour. This test unit we bought with two variable speed 40 horsepower motors. We are able to vary the center distance on the shafts and all of these variables were included in the total purchase price. We've tried several different designs on this light air classifier as I mentioned before, and it works very effectively for the purpose we are trying to achieve. Next along the line is the magnetic separator. We have found by having a light air classifier where it is, that a lot of the paper is removed right off the top of the conveyor; thus our magnetic product is running very clean. We find that the magnetics contain less than 5 percent paper, other than labels. In fact, over the past year, we've been getting around 2 percent paper. This classifier is one which the Bureau built based on one designed in our Salt Lake City research center used for separating nonmagnetic auto rejects. The material is fed in at the upper right, and there's an air stream going from right to left across the horizontal classifier. Lights enter the air stream and go into a cyclone. If you have any massive metal that was not picked up by the magnetic separator, a bronze pump housing or something like that, it's going to drop out on this first conveyor as it will not be affected by an air stream. We needed this as a protection device for our secondary shredder, and it has worked as such. We get a medium fraction which contains all the rags and cardboard and heavy plastics, glass, aluminum cans, wood, food wastes, etc. We thus get a three-way separation. This middle fraction which I have mentioned, the food wastes and the aluminum cans and glass, we put through a trommel. This picture shows a trommel with one-inch square openings. We have since standardized on 3/4 inch diameter holes. We have found that the way we are running our flail mill, that all glass bottles are broken to minus 3/4 inch in size, and we remove all of the glass at this point. In addition to the glass, minus 3/4 inch ceramics, metals, organics, plastic and wood are all removed here. We use a mineral jig to recover a glass concentrate from the rest of the trommel undersize and we crush this material down to 20 mesh in size and go to froth flotation to recover a mixed colored glass cullet. The trommel oversize, this is material that is larger than 3/4 inch in size, passes through our secondary shredder and into the third air classifier, which is a three-stage aspirator. This is a commercial unit made by Forsberg. We've modified it, but it is a piece of available equipment. The box under the three-stage aspirator is where we recover the aluminum concentrate. We have tuned this air classifier to drop out the majority of the aluminum cans. We are able to tune it to remove all paper from the stream. In other words, we can treat all paper as lights if we want, but we do lose aluminum. Consequently we accept a little bit of paper in with the heavies, but we are recovering currently 95 percent of the can stock that's fed to the shredder, and believe it or not, we are recovering about 90 percent of the foil. We then take the heavies from the three-stage aspirator, dry them, and put them through an electrostatic separator. The electrostatic

separator we have is a commercially available unit. The electrodes are charged with 40,000 volts dc, the drum is grounded, and the dried material is fed over the rotating drum. As the material enters this ionization field which is set up, all the material picks up a charge. The aluminum and the other nonferrous metals, being conductors, lose their charge immediately and fall on one side of the deflector plate. The combustibles fall down on the other side of the plate. We get a very good recovery. However, the economics of it are high because of the drying cost of the three-stage aspirator heavies. We are also currently testing Raytheon's nonferrous metal separator, and they have been doing some work in our lab also. Our research is conducted on a relatively modest budget. Our current plans include treating refuse from municipalities which are planning to implement resource recovery operations. In addition to refuse from Monroe County, New York, and Baltimore County, Maryland, we have processed refuse from Tampa Bay Authority in Florida, Montgomery County, Maryland, and several other areas also. We have a small in-house program to upgrade our recovered products and to optimize the equipment in the pilot plant. We also want to improve the nonferrous metal separation. As was mentioned several times, these past two days, we do have a cooperative arrangement with Raytheon and Teledyne, and if any problems arise in their plants once they get them on-line, our facility is available if needed to help them solve their problems. We also use our equipment and everything that we have in both pilot plants for treating specialized wastes from industrial facilities which we feel could possibly be processed with this type of machinery. Traditionally, it has been the Bureau's policy in our metallurgy research programs, to conduct minerals recovery research in areas where technology has not been demonstrated. We develop pilot plants, perform economic analysis, and if the developed process appears viable, we assist in implementing full-scale demonstrations. Once the process is demonstrated and the private sector has a handle on the problems and are operating these plants, the Bureau then stops their research and goes on to other work. Consequently, at the present time the Bureau is not planning to expand their solid waste research program. As I mentioned, several companies are implementing much of the Bureau-developed technology in their plants. Often these plants are utilizing the technology without giving credit where credit is due. When we started our research program, no one else was doing this work. When the full-scale facilities are operating, the Bureau of Mines will have accomplished its goal; our mission will have been achieved. Solving these unit operation problems that we've been talking about yesterday and today should be approached in a fashion not unlike the manner in which the Bureau has solved similar problems in years gone by.

BURCKLE: Thank you, Roger. The next one on my list here is George Trezek, University of California.

TREZEK: Let me begin by saying how our plant got going. As I pointed out yesterday, we first started out as a facility which was set up just to do shredding experiments, and then little by little we added more things on to it. When the EPA laboratory at Center Hill was phased out or disbanded, I

was called upon to receive some of the equipment from this lab, and try to put it together and make it work. Let me run through a little bit of what we are doing. This is a picture of the facility as it now stands (Figure 20). The building back here used to be an old munitions test center, and that's the reason for all of the thick walls because those were blast chambers. The solid waste facility is the part in the back. Packer trucks can back into this facility (Figure 21), and essentially outflow comes out of this part. The cyclone discharge from the classifier is shown up at the top. We receive refuse from two types of places. One, University refuse, which is pretty much 90 percent paper fiber type of thing, and we also have an arrangement with Richmond Sanitary Service, who bring refuse to the lab and take it away when we are finished processing. This particular load happens to be a University batch, which has, as you can see, a fairly high fiber paper content. This material would be typical of the kind of commercial batches that we see, very high cardboard corrugated fiber types of things. Over the 4 or 5 years that we've run this, we now pretty much have the City of Richmond mapped as to what kind of materials you can get from what location in the city. When a truck pulls in (Figure 22) we can pretty much tell where he came from, by what kind of liquor bottles come out, things of this nature. As I pointed out yesterday, we feed the shredder with just a simple front end loader, (Figure 23) and I don't think this would be the way I would do it if I were running a commercial plant, but this is what we had available. We have built and studied air classification, and that is the plywood system that you see in the back (Figure 24). It is something that we put together and have been doing some air flow aerodynamics type of tests on. The ductwork up at the top is the ductwork which leads into the cyclone, which I'll show you later. This is a picture of the back of the classifier. We built this out of plywood for a total cost of about 50 dollars. It happens to work fairly well, gives us about 6 to 7, 8 tons per hour throughput through this. We built it so that the back wall could be easily movable by just removing just a few bolts. This way we can begin to try to look at some of the scaling parameters as related to cross sectional area distribution of material within the column, air distribution, and things of this nature. This is pretty much a straight column except for one baffle, which we observed through these windows was needed to induce some circulation in the material. The heavies come out from underneath the air classifier (Figure 24), come out on this heavies conveyor, and then have a magnet which pulls out the ferrous scrap into this bin. We then take that stream through a trommel and the undersize then goes into a system which is essentially an air table. I found this to be an extremely effective way of cleaning up glass. We come in here, we go one pass through the air table and remove an essentially clean glass fraction. We have a small rotating drum magnet which takes out any of the screws and nuts and bolts which happen to separate out on this air table. We then go back through this air table one more time and are able to get something like 99 percent clean glass fraction. We have taken this material and sent it to a company called Ecoceram, and they have taken that and ball milled it and have made what they call Ecoceram building blocks out of it. So there is apparently some commercial use for this type of material. The light stream coming up from

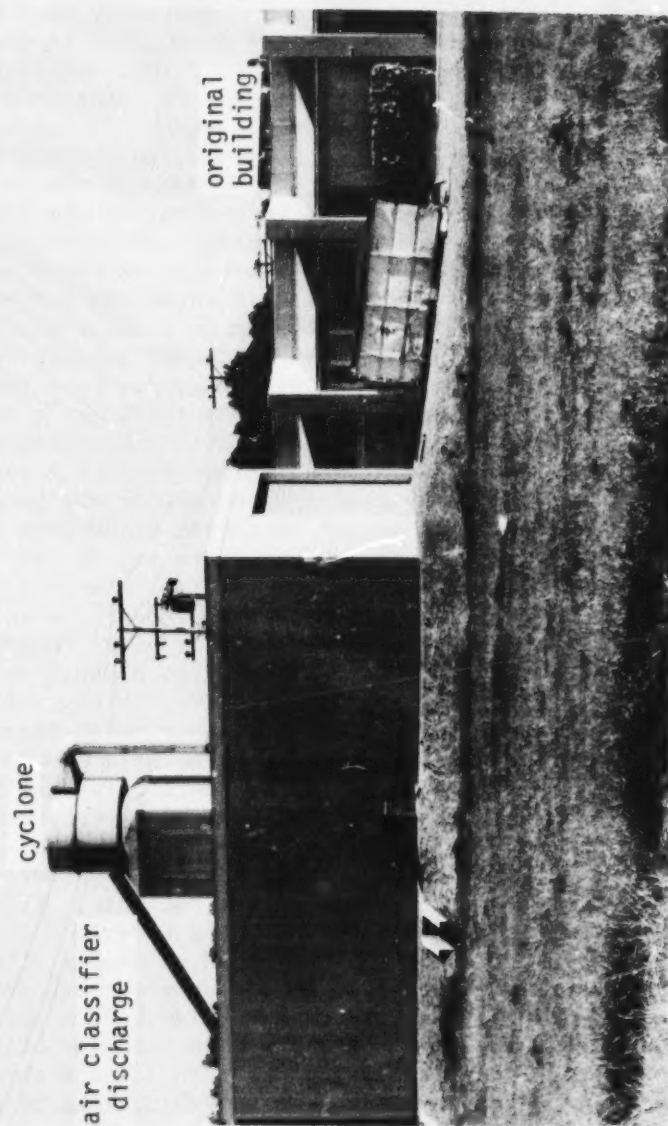


Figure 20. Berkeley test facility.



Figure 21. Packer truck at test facility.



Figure 22. Packer truck unloading University refuse.



Figure 23. Front end loader feeding shredder.

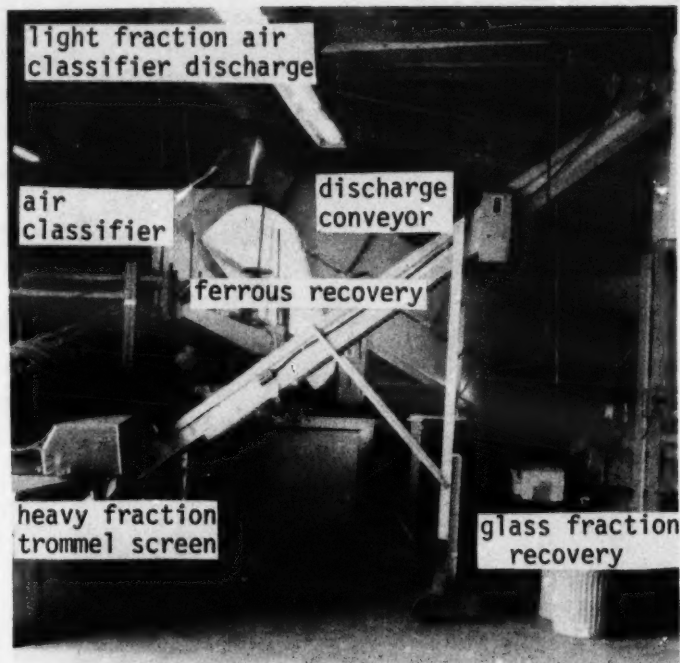


Figure 24. Air classifier.

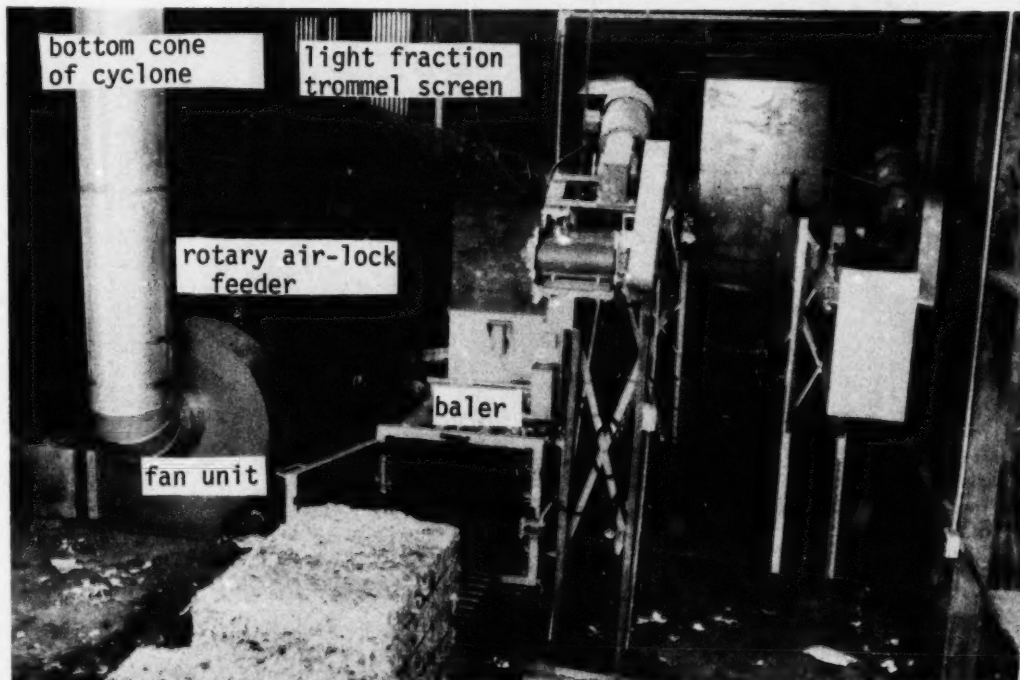


Figure 25. Air lock feeder, trommel screen, baler.

the top of the classifier up through the roof comes down through the bottom of the cyclone. We have experienced a number of problems with air-lock feeders and things of this nature (Figure 25). This is an air-lock feeder which we made ourself, and we have studied different kinds of blades in this air-lock, and try to make it work so that it handles light fraction without jamming. We also, as I said yesterday, went through some screening experiments. We used to have a flat horizontal screen, which was one that was sent over from Center Hill. We've since replaced that with a trommel (Figure 25), and as you can see, have suffered the usual kind of problems. The trommel screen that we made was built so that we could easily remove the screen surface, experiment with different screen sizes, and categorize and study the effect of the parameters governing screening. The screened material then goes into a baling machine. We have looked at some of the uses for mixed paper wastes. We had a project with Consolidated Fibers and Certain-Teed Products in which Consolidated Fibers would come pick up this material, take it to Certain-Teed Products, and they would pulp the baled material and use it directly in the production of roofing materials and other products which they manufacture. The cyclone discharge is arranged so that no material goes through the fan. The air lock drops the material onto a conveyor to the trommel screen, the air flow goes through the fan and is exhausted through a filter.

This is an example of one of the bales which came out (Figure 25). As I said, these have gone to Certain-Teed Products. We have done tests to instrument these to measure temperature rise of the bale over some period of time. That gives you a fairly good indication of how well the screening processes have been carried out. I'd like to point out that we have done experiments to see what could be done with the minus fraction from the trommel, which would normally go into a drop box and get taken back to the landfill. We've gone through a number of digestion experiments in which we digested this kind of material with sludge. Here is a small-scale unit (Figure 26) which we started, in order to get some basic ideas about the behavior of the various controlling parameters. In this set of experiments the control was a 100 percent sludge digester along with the refuse sludge system. After this we went to a 400 gallon size unit in which refuse mixtures are fed in through this feeder. This is a double wall concrete cylinder which is heated by a hot water tank heater. This is shown now with the cover plate off. There's a mixture which goes into the top of this, and we've done some work on what kind of mixing problems you get into when you start getting into sludge refuse digestion experiments. At one point we were very curious to see what you could do with fiber recovery if you had a good front end system ahead of the fiber recovery operation. So, one of the things we've set up is to take the screened "accepts," which we call them, or essentially screened light fraction, and subject it to a pulping process. You need to essentially slurry the pulp, but not the plastic. We worked on that problem. We then found you could do that, then go through what we call a plastic removal dilution operation, followed by some cleaning operations and then eventually come out with pulp. I'll show you some slides of that (Figure 27). We've also looked at the kind of



Figure 26. Incubator containing digesters.

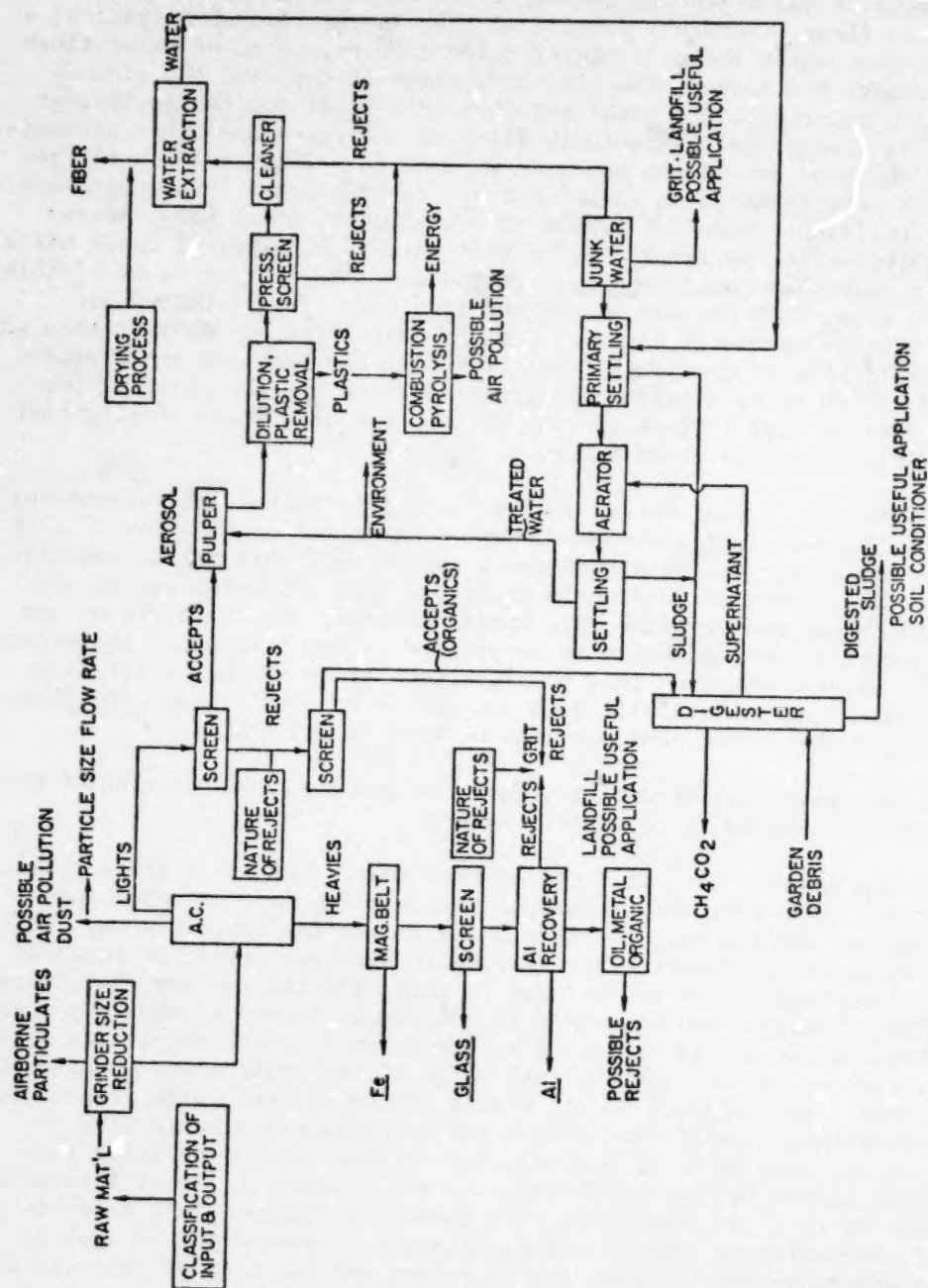


Figure 27. Process flow diagram.

water treatment problems that you get into if you had a good front end system or if you didn't. This is a picture of the top of the pulper, which has now slurried the pulp or the light fraction. You can see large pieces of plastic and styrofoam and all sorts of other things which are now liberated and float. Here's a picture of the plastic removal operation; a traveling screen which the pulp slurry comes down on. Jets of water flush the pulp through the screen, the plastic remains on top, and the clean slurry is now diluted to the right consistency so that you can go through a centrifugal cleaner and essentially clean up the fines and other contaminants. We've grown out of the building we were in. This is a plastic removal screen, the pipes going in and out are to be hydrocyclones which are inside the building. Here's a sample of a hand sheet which was prepared from a light fraction material. We've sent this to a number of paper mills and so on to see what could be done. By the way, the heating value of this material is about 7300 Btu per pound, and it's very clean. We've also looked at this as an energy source. I might just point out we sent this as a feedstock to some of the people that are doing fermentation experiments, and they found it to be a reasonably good feedstock for that kind of processing. This is just a close up view of the same hand sheet showing that it is possible to really clean fiber.

Now one of the things that we are just getting into in the lab is studying the burning characteristics and acquiring a fundamental feeling for some of the combustion aspects of densified fuel. We've made this small combustor in which we have a way of feeding in pellets. This combustor can be co-burned with either gas or oil. This grate vibrates, and therefore we can flow the material down and begin to study some of the combustion characteristics. We are now changing this configuration to go through a rotating basket in which the pellets will drop out and be rotated through the flame zone. I think that gives some overview of what we are doing.

BURCKLE: The Department of Defense, Navy, is going to give us a brief overview of the DoD program in resource recovery.

HURLEY: I don't know, John, if I can address that. That is a large topic. I would like to at least convey some of the thinking that has gone into what we call an experimental operation. We picked the Norfolk area. We are about to advertise in Commerce Business Daily for expressions of interest. By way of background as to how we came to this, I'd like to say that there is definitely thinking and agreement of consensus, backed by the Navy organization responsible for planning and construction of shore facilities for the Navy, that we can utilize the fuel value of the solid waste we have been throwing away. With respect to the rising prices of fuel, with respect to the EPA Guidelines, (which some people say is pressure; I would like to think of it in terms of an incentive), and certainly a DoD position that says we will indeed follow the Guidelines, and henceforth, or at this moment, start planning to be in compliance with those Guidelines. It's a combination of circumstances that, I think, causes an organization to look at what they are doing and how they are operating and making a decision to do

something about it. In looking at the number of organizations and the regional concepts, it seems like a rather endless number of options are available. With some activities in close proximity with rather large municipalities, and the option of joining in a municipal system very promising, very likely, and other locations, small systems, look like they have to go it alone, and other locations are faced with being in the proximity with other military installations, and the idea of inter-agency cooperation becomes a difficult aspect of arriving at how you introduce projects and how you introduce a cooperative venture. So it seems prudent that both the Navy Environmental Protection Program and what is now called the Energy Conservation Program should join forces and bring together an action that would accomplish the objectives set out in both of those programs, so that has been a bit of a task to bring that cooperation and understanding about. At this point we have two programs joining forces and we intend to go with a full-scale, I'll call it prototype, experimental unit in the Norfolk area, to try and determine what degree, and with what problems, and at what cost, we should be interested in or should be trying to make an RDF. I'd like to answer whatever questions I can at this time, and that's about the extent of where the project is right now. There is interest in terms of putting it on a DoD basis, which means to what degree it can be related to the other services, and to the responsibility that belongs to an organization called Defense Logistics Agency, who have the assigned responsibility of doing all of the DoD marketing. The situation today is that the trash at the curb on the military installations belongs to Uncle Sam, and the NAVCOM, the DoD, control rules have been changed to accommodate or create an incentive so that the installation that wants to practice this resource recovery operation can indeed retrieve the funds that it generates; they don't go back to the U.S. treasury as formerly was the case. So it is with some incentive, the ground rules have been changed, that I think has precipitated some of the action over the past year. To what degree the commanding officers will recognize and get information that helps them make decisions, what options they have locally, are yet to be seen. But as I say, the DLA, the Defense Logistics Agency, has the assigned responsibility for handling all the marketing, which means that all materials that are recovered and are to be sold are handled through that organization. They have people called Defense Property Disposal officers at most installations, who handle this, who determine what the market is, and how you recover resale material. I think, John, that in essence is what we are about to launch into, that's relative to this group and their purpose.

BURCKLE: Thank you very much, Steve.

HOLLANDER: About nine months ago, maybe it was a year ago, there was something in the Federal Register mandating that a program like this be undertaken for military facilities adjacent to population centers or within population centers, having a certain minimum waste generation rate at the military facility, that they should erect the facility for resource recovery and also size it to accommodate some if not all of the community wastes.

HURLEY: I think you are referring to the EPA Guidelines.

HOLLANDER: Well, it was in the Federal Register; it referred to military installations. It seems to me that it was directed at Federal facilities.

HURLEY: [Unintelligible] option of going in a region or going it alone.

HOLLANDER: If the waste generation rate at the Federal facility was beyond a certain point, 50 tons a day or 100 tons a day, something like that, if they had that much waste, singly or in concert with other Federal facilities in the area, that whatever they built should also try to accommodate the supporting community's waste.

LEVY: You are referring to the Federal Facilities Guidelines, and I don't have copies of them with me, but I think you are misinterpreting it. There is a mention of the joint cooperation, but I think it was more intended to be the other way too, that the facilities would cooperate with the communities and their systems, or maybe it opens it for either, going in either direction. It is the Federal Facilities Guidelines which are available which you are referring to.

HOLLANDER: Is there something more current that this directive about a year ago?

LEVY: No.

R. FREEMAN: I'm Robert Freeman from Stanford Research, and we did the work for Steve. What you are referring to is the Guidelines that said that any one Federal facility within an SMSA that generates at least 100 tons a day and all of the Federal facilities from that area at least 100 tons a day, at that time the largest Federal facility would become the lead agency for other Federal facilities to take care of and administrate the garbage. They could choose to either utilize a resource recovery facility, or establish a resource recovery for gaining their energy, materials, or both. EPA promulgated the Guidelines; the Guidelines came back, they broke out the areas of responsibility, the Navy had nine areas of responsibility, the Air Force has one, the Army four, and so on [unintelligible] 100 tons per day scale, and this information would then fall into the Guidelines that you're talking about.

FUNK: How does this request for interest tie in with the Naval operating base and the existing waterwall incinerator utilizing the plant waste from there right now?

HURLEY: There's no connection. We are going to that area because we have a variety of military installations in the area, and we hope some market, too, for the materials.

FUNK: Are we looking for outside wastes coming into this facility or are you looking at a 100 tons a day facility?

HURLEY: We are not looking for outside wastes, but I think the opportunity exists, and if other people can see a need for joining in or using the

facility, I think the option ought to be kept open. So I don't think it should be restricted, and I certainly haven't heard anybody's intent that it should be restricted to just military operations.

FUNK: Well, the reason is that we are actively involved with the planning district there and the Navy, and there's quite a program that's launched and there's quite a bit of momentum to be utilizing nearly all the waste in the area.

HURLEY: I understand the question, and I can tell you that our organization, and the geographical split in our organization, and that is our [unintelligible] office who handles that location. They are aware of the project, and they are trying to keep people involved in the planning clear so that local confusions do not exist, in which an experimental setup would come into a region and it would be misconstrued as a project to solve a local problem.

RIGO: The key to selecting Norfolk was that the plant was not needed. There is no problem of solid waste management for the Navy at Norfolk. The Norfolk incinerator and the Portsmouth incinerator, both of which are under-utilized, provide excess capacity. That is the reason the site was selected, because we were afraid if we went to a place that needed the plant or had a solid waste problem, the plant could not be used as a test bed, but would be forced into a production mode.

CHISAMORE: In Ontario the Ministry of Environment is, I guess, a bit unique in that it's a regulatory agency and over the years has also been a funding agency in terms of providing capital funds for sewage and water works, and three years ago the same funding was extended into the solid waste side of it. At that time a commitment was made to build what we have termed an experimental plant. It's experimental, basically, in name only in that we did decide at that time to go to the off-the-shelf equipment. You've got the smaller scale in terms of shredding, 40 tons per hour. It is being set up in such a way that we can shut it down at will to determine efficiency or make changes. Certainly no municipality is depending on it for disposal purposes. We have incorporated as part of the receiving area a 600 ton per day transfer station so that if the plant is shut down the waste can be transferred. The brochure which I brought with me provides a description of the equipment which has been installed. As a highlight there are two stages of air separation, one of which is patented by Vic Brown, who was acting as a sub-consultant to our main consultant. In designing the plant layout, we wanted to maintain as much flexibility as possible to explore both energy and material recovery. The plant will be used to demonstrate technology and also for market development purposes. Many industries have expressed an interest in using RDF; however, the obvious problem is how to provide a sample, which in some cases will exceed several hundred tons. The Experimental Plant will give us the capacity to provide necessary samples. The Province has also made available a capital subsidy for front-end plants. Under this subsidy program the Province would finance and construct the plant and recover 50 percent of the cost from the municipality as a user

charge. This offer was made initially to six municipalities, but to date, because of many of the uncertainties which were described yesterday and today, these plants are not proceeding at this time. In addition to the Experimental Plant we are encouraging demonstration projects. Yesterday I mentioned the project with Ontario Hydro, which is a public utility. Right now we are waiting for environmental approvals. Ontario strongly favors environmental assessment and even though the Province has some funds in the demonstration project, we are experiencing the same problems of obtaining environmental approvals that the private sector is. We also have an agreement with a cement company to use what we term the light fraction, which is primarily paper and plastic film. This autumn we will be doing some test burns in their kiln. In the Experimental Plant we have a small Consumat system for energy recovery to provide some information which may assist small municipalities which are considering this type of system. In addition, the plant has a 50 ton per day mechanical composting module. The plant is set up on a modular basis and facilities will be made available to manufacturers who wish to test their equipment. Any information gathered from this plant is public information. The plant is designed such that you can see as much as possible and will be available for tours. The transfer station will start up next month with plant operation contracted to Browning-Ferris Industries (Toronto) Limited. The remaining part of the plant should start operation in late summer, so it's a little premature to schedule any tours yet. If there are any questions I would certainly be glad to answer them.

FISCUS: Have you made any plans to monitor or measure in any way the environmental emissions from the various processes that are incorporated in this plant?

CHISAMORE: Yes, there will be extensive monitoring done throughout the plant on unit processes as well as emissions to atmosphere from the Consumat unit and dust collectors.

FUNK: When did you say you were going to be operational?

CHISAMORE: The transfer station will be operational next month; the processing side of it in June this year.

FUNK: June of '77. Tours when?

CHISAMORE: Anytime after that. Actually we have had some tours. People have been going through already, but certainly at this stage it is rather difficult, you know, in the final stages of completion.

HOLLANDER: Is this going to be in Toronto?

CHISAMORE: The plant is located in North York, which is one of the boroughs of Metropolitan Toronto.

PURCELL: If somebody asked you what is particularly different from your plant from what we've been talking about, what, in a word or two, would you say?

CHISAMORE: The basic train is similar to that which would be used for producing RDF. It does have additional features, which I mentioned, to provide flexibility for both material recovery as well as energy recovery. In the early stages we have not included froth flotation or aluminum recovery in the plant layout. We are hopeful that the private sector can recover valuable materials from plant residue on a commercial basis without the need for financial involvement on the part of the Province.

BURCKLE: Any other questions? In view of the time and our desire to get on into the summary session and the nebulous nature of Area 5 here, I think for the purposes of the workshop we'll skip over this particular question and suggest that people give it some thought after they've returned to their respective offices and homes and determine then if they would like to comment on Item 5 when they review their comments, before publication and perhaps send in something in written form on this particular aspect. I feel personally that these systems are going to be built at some point in time, depending on the cost of fuels in the future, and that left to its own, it's a matter of time. I think the basic question rolls around to, do we want to furnish some sort of incentive as in 5 or another type of incentive that would accelerate the employment of resource recovery systems on a relatively nation-wide basis? If so, perhaps what is really the best way to go about this? I would be very interested in your opinion and comment.

HURLEY: I think the thing that I heard and have experienced is that there is little interest in the organization I'm with when you talk about national problems or big city problems, or 1,000 ton unit, but as soon as it became a realization that small activities had to do something and could possibly do something, and I think that's when I got a little attention with respect to what can you do for the organization. I think the project we are venturing into is one that it has something hopefully in it, it has an objective that returns something to the organization, whether it's fuel or something else. That to me is the thing that triggers the people to make a decision. So we hope that our project will indeed deal not only with small military installations and other small communities like it, but also many of the problems that have been discussed here in the last day or so.

SESSION 5: SUMMARY AND CONCLUSIONS

David Berg, Moderator

BERG: This is Session 5: the final session. I feel a little bit like a desperate man right now. I never did like trying to do summaries, so I guess at the outset I'd ask you all to bear with me as I try to do the best I can. I guess the best way to start is to go back to the beginning of why we are here. One way of looking at it is that we are in a period of fuel crisis, we have at the same time an environmental problem which is really affecting many cities around the country, which in the estimates of all the

experts will only get worse as time goes on. There's a generally recognized agreement that greatly expanded use of RDF and of materials recovery could greatly help, or at least to some extent help, ease this crisis, and certainly to reduce the impacts of future crises. What we are talking about, then, is trying to telescope the birth of an industry from 50 years to 75 years to maybe 10, or 10 more. As I said, this is partly because of the energy situation that we might want to do that, but it is also because industrial society has reached a state of development such that we don't have time the way we used to have time to develop the secondary systems and the analytical data to operate. We have work-place standards and environmental standards and competitive uses, and this is not the same ball of wax that we used to have before; the system is much tighter. There's much less room to flex. Having said those general remarks, where's that leave us? I suppose that as I sat here the thing that struck me the most about the meeting was the very strong interplay that dominated the discussion. It seems to me that on the one hand we were talking about near term problems, and on the other hand we were talking about longer term optimization. The group was much more comfortable talking about the near term problems, naturally, but I must say that it seems to me there was a commendable struggle that we all put up to address the pathways that are going to hasten optimization of resource recovery and implementation of optimized systems. Maybe I could bring this observation home by illustrating. Immediate issues seem to be raised most frequently where this observation that immediate ease issues seem to be raised most frequently. The municipal implementers continually stress their need for operation and maintenance costs, revenue estimates, reliability data in planning systems and improving ones they have. The planning engineers continually stress that they also have data needs. They need to understand equipment operating experience, and they also could use sets of performance specifications. The system designers expressed their desire for data to predict unit operation performance, and then all that recycles back to develop improved unit operations and the data is a key to developing improved unit operations. So lack of data at all levels seems to be impeding both implementation today and in the near term, and on the other hand, development of new systems and new unit processes. The last point on that is that the need for comparative design data was one clear point that was raised. A design handbook for the short term, for the longer term, R&D in an orderly fashion seems to be recognized as being needed on the parameters of processes, again so that we can develop systems that will be better in the future. Thanks to the session chairmen I have several pages, which I will try to skim through quickly, of summaries of each of the sessions. I took the liberty to mark each of them up, and I'll try to run through these as quickly as I can. Maybe what I will do is pause at the end of each one and if people would like to challenge or modify things that have been said, or add additional remarks that they feel are particularly important with respect to those sessions, this would be a good time to do it.

Session 1 was the Systems Process Design discussion. Here I heard Harvey Alter mention an outstanding point; he said there is no state of the art. During this session workshop participants seemed to me to note an extreme

lack of information on virtually all aspects. There were several areas which were identified as being most important, areas where more information or research is required. Four stood out. One, materials handling systems; second, scale-up of equipment; the third, quality and composition of raw refuse; fourth, specifications and requirements of fuel produced. There was a strong interplay between the third and the fourth, the quantity and composition of refuse and the specifications and requirements of fuel produced. Process design, of course, depends largely on the specifications of the fuels, and parenthetically I would note that little is known about what these specifications should be. On the other hand, system process design is also highly dependent upon incoming refuse quantity and composition. The accuracy and reliability of this information affects the economic performance of the system, as well as the technical performance, so the trade-off is posed between the quality required by specifications, the user's perspective, and the economics of production, the municipal perspective. Of course, caught in the middle are A&E firms and EPA, ERDA, the Bureau of Mines, and the Defense Department, which are trying to be facilitators. Two other important points or items which were singled out were sequencing of unit operations and modeling of alternative systems, which seem to be generally considered to be important topics. On those the consensus seemed to be that there's insufficient information available to make specific statements about optimal sequencing, and there's insufficient information to implement or verify models that would be of much use at this point in time. Also there seemed to be no good comparison of the alternatives; this point came out strongly throughout. Another outstanding consensus was that there are a lot of variables. (I told you it is a disaster to try to summarize.) One point which will win no friends is that trade secrecy and proprietary information was felt by many people to be a real barrier to information flow, and this is a real counterpoint to the concern that people seem to be expressing that we should be increasing the information flow. This impediment will affect the ability of the players to improve design and develop new unit operations as well as systems. That's what I had on Session 1. Is there anybody who would like to comment on that or add points?

ALTER: I'm not sure that trade secrets and proprietary information have to be an impediment. I think we would move along faster if there were more room for invention in a proprietary position. I think we can advance, as we talked about this morning, at least advance the methodology for obtaining comparative data, even working with the people with proprietary systems. We can share each other's experience and help the proprietary positions lead to profit. The profit leads to incentive, and we will move faster. I don't like the word impediment.

BERG: I think there is merit to what you are saying. That debate is reflected pretty clearly within the government itself in the various rules that apply to government support and patent rules which apply, where the energy, particularly the atomic energy program, used to have a much more liberal clause in there permitting much more proprietary information to be protected than did almost all of the other R&D areas. I think that with

the advent of the new legislation in solid waste, we are moving more in the direction of the Atomic Energy Commission approach, which is now ERDA's approach, where there will be more protection. I suppose you are right. On the other hand you have the problem that there is a reluctance to expose systems to comparative testing. That's natural in a competitive situation, but it does make more difficult the data collection and sharing.

ALTER: I think that as proprietary systems are developed, and the developers gain experience and confidence, they will make more information public. They want customers to be aware of their systems, and they want the customers' consultants to be in a position to pass judgment on the systems. The only way they can do that is to make the information public. At the same time, I sympathize with them for not wanting to release information until they have confidence in it.

BERG: Any other comments on Session 1?

CAPPS: Dave, what about the site specific market or users? Wasn't that the thrust?

BERG: Yes, I think so. Session 2 was on Unit Operations. Within that session, the general format was broken out in materials handling, size reduction, separation, and process control. Again in an observer role, I would say that much of what was said with respect to the system design questions or topic applied to the equipment session. First, it was widely noted and restated in each of those four aspects of the discussion or parts of the discussion, that there is an overall scarcity of performance data and an overall scarcity of parametric data, especially with respect to comparative performance data, performance over a wide range of operating conditions, and the relationship of input and output parameters. Looking at it from the short term versus the long term perspective, there was no general agreement on how much data is needed, what form it should take, or how to get it. There was some comment on the proprietary problem again during that session, although within the constraints of what Harvey was pointing out. There was also a general feeling that equipment works, but I would say that people recognized that what equipment exists today is clearly suboptimal equipment, primarily equipment that's been adapted from other industries. There were no specific major equipment problems identified to prevent plants from being built; I think that statement would be accurate. Steve Lingle put out a trial balloon that Atlas storage bins were an impediment, but there seemed to be a feeling that that was not the case. Materials handling equipment seems to work, although there are problems. I think that that was the thrust of each of the areas that we talked about. On the other hand, looking at this thing from the longer term perspective, there was a need to understand, or people recognize the need to understand, fundamental parameters. George Trezek's paper or discussion gave us a pretty good snapshot of how that kind of data is useful and can be made useful, and I think reinforces the thought that we need to develop more data like that. As Peter Ware pointed out, we need to extend the state of the art of resource re-

covery from an art more towards a science, and it's that kind of data that will allow us to get there. Running quickly through the specific comments on each of the four parts of the discussion: With respect to materials handling, it seemed that people agreed that it is difficult to handle wastes; again to repeat, waste handling is an art. Secondly, equipment choices for storage and retrieval are limited. They are largely an adaptation of equipment designed for other materials. Size reduction: There's more experience with field operation of shredders than from other unit operations. We can shred refuse, but as Harvey Alter pointed out, the state of the knowledge is pathetic. Again, there's not good information on comparative performance, nor is there on the relationship of input and output parameters. Third, other types of size reduction equipment need to be explored. That was a clear conclusion. With respect to separation, there was one major point I think: That air classification was recognized as an area where there is a great deal of uncertainty. This particularly was pointed out as being an area where we are dealing with a subject that's an art form today. I had to feel somewhat amused when Harvey was describing the Triple/S classifier (I guess it was the Triple/S) that you are just putting in where you can vary just about every single parameter in the entire unit.

ALTER: No.

BERG: It was the experimental one that NCRR is putting together, where you can vary virtually every parameter from the angle of the baffles right on through to the air flow and what have you. In the process control part of the discussion, important considerations were raised with respect to dust control. The feeling seemed to be that the existing technology could be applied to solve these problems. There was a very gingerly discussion on the health implications of dust. People seemed to not want to touch that one with a 10-foot pole, although Arnold Chantland pointed out very aptly that there is a tremendous sensitivity, and others as well pointed out, there's a tremendous sensitivity to this problem. There seemed to be an agreement that we should get thorough information, but at the same time people are aware of the tremendous expense involved, on the tune of, I would guess, in excess of or nearly 10 million dollars, by the time you finish doing epidemiological studies. A very dismaying dollar figure. With respect to fires and explosions, the need for a design manual for shredder explosion control was pointed out. That's the notes that I have for that session. Are there any comments here?

ALTER: Where did the 10 million dollar figure come from?

BERG: Out of my head; nobody said that. I just made a guess. We'd been talking about that a little bit in the office. It just seems like it would require a fairly enormous amount of monitoring, and that individual epidemiological studies are just expensive to do. MRI is gone, or at least Larry Shannon and Maurie Schrag are, so they are off the hook, and I won't even look at you. Are there any other comments on that session?

RIGO: I think one thing that you missed that was mentioned in passing was that there is need and room for some blue sky work, probably low dollar limit, but where people are inclined to sit back and reflect on something new.

BERG: I think that point was brought out. Maybe we should take a quick break from the sessions and announce that there is no winner in the pre-processing renaming sweepstakes. Don Walter submitted the worst suggestion of all, that was mecachemical or chemimeca or some combination of chemical and mechanical. Don, you owe me a drink. Steve Hathaway had the other alternative. Steve Hathaway's suggested title was beneficiation (I'm choking on the word here), which is a term that has been applied to coal beneficiation, and naturally has some applicability here. It is just that, Steve, it lacks a little bit of zing. So I guess that what I should do is extend the sweepstakes for another 20 minutes.

Session 3: Technical Obstacles. Here a big duality was pointed out. Again this goes back to the summary remarks that were made in the beginning. There's a clear need for data on existing equipment, yet there's a need for better unit operations, better systems configurations. I think that at that point we came out very strongly during that session. As Harvey put it, anything we can do to reduce technical obstacles and risks will be helpful, and that seems to me to sum up that session fairly well. It was notable that until the end of the session, people were really a little bit unwilling to list the major technical obstacles. I think that they came out by implication during the course of the meeting, or during the course of that session. Then at the end they came out in spades when we did that exercise. There may be about eight to ten points; I'll go through these quickly. The first, again, the need to accumulate data on process and unit operations performance to better inform implementers as to the risks and uncertainties of resource recovery came out very strongly. To go back to a point I made in the beginning, the type of data differs for each of the different audiences. The municipal manager has one perspective, the A&E firms another, and the system designer a third. From that we have a bit of difficulty in putting together an approach to get together the data that will be useful to all parties. A second point is that the necessary information may be obtained by studying either full-scale plants or separate unit operations, and recognizing the concomitant difficulties of each, we were unwilling to say which was the most beneficial approach, although I think that there may have been a slight leaning towards separate unit operations. If I recall back to the first session, there seemed to be some comment that EPA might have had a better bigger bang for the buck if we had shaped our expenditures differently over the years. Part of the responsibility of obtaining the data may be relegated to suppliers through performance bonds and related mechanisms. This was another point that was brought out. I guess that that would be as an outgrowth of the bonding requirements. The fourth point, there is a need to coordinate the gathering of data so that it may be interrelated and compared later. This may be done by working toward some sort of standard method of evaluation for each unit operation, or each class of unit operations. Another point is that once evaluative data are accumulated on a comparative basis, these may be assembled into design handbooks. There was a bit of discussion about design handbooks. There were at least two or three design handbooks that were offered, one by EPA, I don't recall the

others at this point. NCRR's, and there was a third. I think that people felt that at this point we don't have an adequate design handbook that can be used by everybody. Developing a better design handbook seemed to be an objective that people would like to see pursued. Then Harvey ran his Delphi exercise.

ALTER: Do you have any results?

BERG: I have some quick results here. We didn't have our computer working, but thanks to Harry Freeman and Jim Smith, we came up with a quick summary here. The number one item in terms of first place votes for high priority work was Number 1--Determine Optimal Arrangements of Unit Equipment. The topic that had the largest number of total votes for high priority was Comparing the Performance of Various Types of Shredders. Other research needs that received, I would say, the higher mentions were Emissions from Processing Equipment, Evaluation of Other Potentially Applicable Equipment, Determining the Effects of Pretrommeling (Number 15). So that's Numbers 1, 2, 4, 5, 15, and under economics, Number 36, Developing Effective Accounting Methods; and Number 39, Determining Equipment Operating and Maintenance Costs. There was one fence hanger, and that was Number 3, Determining Effects of MSW Characteristics on Processing. That had a moderately high number of votes, putting it in the high priority category, and it was tied for second place as being most mentioned for low priority. What can you expect from 48 people? The most unpopular items were: In first place, Determine the Effects of Magnetic Separation. As I said, tied for second was The Effects of MSW Characteristics on Processing, Number 3, and also Number 27, Evaluating MSW Segregation Prior to Processing. Other low lows were Number 26, Evaluating Receiving Facilities; Number 19, Evaluating the Effect of Drying on Combustion Characteristics of RDF; Number 16, Determining the Effects of Drying on Bacteria and Virus. Now if you looked at it by the Roman numeral groupings, numbers I through XIII (this is an incomplete compilation based on the ones that were easiest to pull out), there were 30 high priority ratings in Category I, the General area. Category XIII, Economics, had the second largest number of votes. Category II, Shredders, was mentioned third most frequently. Category IV, Air Classifiers, was mentioned third most frequently, and Category IX, Storage and Retrieval, had a high average, although not a high large number of total votes, perhaps because there was only one item in there. There were only five mentions, but that was an average of five, which would put it up there. In Category V, the Effects of Pretrommeling was a very high rated one, but the overall topic, Screening, was not. Now there were three categories that stood out as attracting the least interest in terms of research. Those were Category X, Receiving Facilities; Category VI, which was actually mentioned more frequently, that's Dryers; Category III, Magnetic Separators, which had the highest average of all and the highest low rating of all; and Category VIII, Conveyors. One other point on this session is that the immediate and short term needs for data and unit operation comparisons seemed to dominate the discussion, but wide recognition was given to the need for basic parametric research with respect to theory, unit operations, and systems configurations.

There was a major action suggested, perhaps it was the strongest action or most strongly advocated action in terms of a priority for follow-up, and that is the suggestion that we have four ad hoc groups to explore methods for evaluating unit processes. Maybe we can come back to that one. That concludes my summary of that session. Are there any comments? Harvey, you can't say anything about my calling it a Delphi exercise.

ALTER: I thought all oracles of Delphi were false.

BERG: That's the reason why you weren't supposed to comment.

Session 4 scarcely needs summary, so I'll limit myself to five quick points. The first is that there is a need to exercise all of the modes of R/D&D, from pilot scale through full-scale demonstration; this seemed to be an accepted point. Scale factors seemed to be extremely important to those using the data produced by any research or test program. Third, there was a dual preference expressed for gathering the process data for operations, and that duality concerned the scale. There was a strong set of opinion that we need to collect data on large-scale operations--30 to 50 tons per hour at pilot. On the other hand there was also a strong suggestion that we should be working more in the small-scale area. This gets back to a point which was brought out strongly by Herb Hollander, and that is the need, perhaps, to start looking at stokers and industrial size boilers as a potentially large market for using the refuse-derived fuel. I think that that was a view that was challenged, particularly by Mr. Fay. My feeling is that refuse-derived fuel in densified form is new enough that people just haven't really made up their minds about it; it will just take a while before people are willing to say that the small-scale systems are the ultimate target for refuse-derived fuel. It seemed that there was an advocacy for more research in that area. The fourth point would be that many options are being explored and none should be cut off. That seemed to be the feeling. As Roger De Cesare pointed out, we might even want to resurrect some older systems that haven't been explored as much recently to see whether there is something we can learn from that. That goes back to developing basic parametric data and also trying to continue our optimization work. I guess the bottom line comment was the most disquieting of all to me. That is that you didn't make my job easier or that of Don or the other government representatives here. There just wasn't a clear consensus for how the government should go about conducting its research programs. So about the best thing I could do is weakly plead for you to continue thinking about it and to get in your written thoughts.

WARE: I think I would like to make a comment or two in this summary section that has been overlooked, and that is the motivations behind pursuing any or all of what we've discussed in these last two days, because there are benefits for all, but not sufficient in a lot of cases to activate any of these programs whether they be R&D definition, system development, equipment improvement, or design. Ultimately, subject to the American way and human motivation, there has to be dollars at the end of it. There are going to be

different benefits for different people. The cities in a lot of cases have to have these systems; they may well get revenue from them; the architectural and engineering contractors will make their 10 percent by pulling together technology which they have begged, borrowed, stolen, or invented. The manufacturers of equipment will make a profit ultimately. They have to be motivated in the first place to design the stuff. The person or organization right now that stands to gain the most is the system developer, to mention but a few Monsanto, Union Carbide, ourselves at Oxy; and they are the only ones for now who are going to commit a tremendous amount of corporate money to the development of processes. That's not to say that cities don't have to come up with front money when they build plants, but as far as pure R&D is concerned, the bulk of it is going to be performed by the larger companies who have got the resources and the motivation to do the work. So it's all very well and good for us to sit here and define the things we would like to know more about. The fact remains that the only people who are going to do anything are those that really want it and will gain from it. That reflects our position and those of the other major companies involved. There are some areas where I think the Federal government should invest money, not to our benefit or to other companies' benefit, but on general subjects. One of those is the discussion of disease problems or potential problems associated with these plants. That wouldn't invade proprietary areas, it wouldn't threaten or even interfere with marketability of these systems, so that the Federal government can independently be involved in that type of work and should be so. Ultimately, systems design, unit operation, efficiencies of pieces of equipment will rest, at least for the present, for the next few years, with the system developers. I don't think you can overlook that. I recognize the value of setting up ad hoc committees to develop comparative methods. ASTM type procedures would be fine. I wouldn't be surprised if the major system developers will comply. On the other hand, you can't make them, and they don't have the motivation. You must understand that why should they define how well their air classifier works now, when first of all they don't know, and secondly they sure as hell don't want you to buy the other person's. So there will remain a mystique, and until the system developers come up with their own methods of evaluating them, you can't hope to do it as an independent body. So getting back to what happens with R&D, which is, I think the essential ingredient of this session, it will remain with the people that have the money, the people that stand to gain the most from it. That may in some cases be the cities; I would like to see more, but I recognize the money really isn't there. It will principally be with the big companies, and I hope the Federal government will recognize the advantage of investing their funds in general subjects, particularly disease. My last comment is that I had come to this session expecting something quite different. I expected a lot of "hands on" practical people to throw out their ideas on specific technologies on how well conveyors work, whether a pan is better than a belt is better than a vibratory, etc., whether a hammermill is better than a ring crusher, etc. It didn't happen. In that respect I was disappointed; I think I may have misconceived what this whole thing was about. I did enjoy meeting a number of people who have similar

interests. I think it may be to our mutual advantage to set up specific workshops where the goals are well recognized, where you have plant managers and maintenance superintendents thrown together and forced to discuss things, where you have policy makers, city government, corporate management together to discuss the direction in which the industry needs to move. There needs to be these types of interfaces. Right now they rest more in the form of requests for proposals and on an individual basis. I think that's where we ought to aim ourselves in the form of committees and further meetings. Otherwise I have enjoyed meeting all of you; I've benefited to those limited extents.

BERG: Are there other comments at this point? You got ahead of me a little; I was going to get into future steps in just a moment. Maybe I could just back up for a second and open a question, not offer any summary. We've kicked around just about every aspect of the R/D&D business. Maybe we could just go around the table quickly (of course everybody doesn't have to stick in their two cents worth) but it would be very helpful, I think, to all of us to get your bottom line statement: What should the government role be? Peter's given us one view; it certainly has merit. If government is the facilitator, what should that role be?

HASSELRIIS: A thought occurred to me which follows directly with your comment. The one area that I think a lot of us feel we could use government help is the government-created problem. If the government agency creates a problem for industry, maybe it should help solve the problem that it created. Some of the things that EPA brings up which relate to environmental problems and health problems are created for the good of the public, the investigation is created for the good of the general public, and the solution is perhaps a responsibility of whoever creates the problem for industry. For instance, if you want a company that operates a boiler to stop polluting, then you can also help that outfit to find a way to stop the polluting. They're very complementary. If you raise the question of health hazards, it's also an obligation to help solve the problem. You mentioned that the health hazards is one of the stickiest problems, and that is probably why a lot of us feel that it would be very helpful, but don't make the problem worse at the same time as solving it. That is just a comment I couldn't help.

BERG: Well, now, you throw out an option there that the government could get involved in solving some of these problems. When the government helped pull together the research that has really been going on outside of the government and identified sulfur dioxide as a problem or sulfur oxides as a problem, the government's response was to pour probably 50 million dollars over the last 8 or 10 years into developing a flue gas cleaning system. One way that the government could serve in the resource recovery area would be to develop or to pour a fair amount of money into developing a base line system for resource recovery. Now that wouldn't be a big hit with companies like Oxy or others that have put a lot of money in so far, I don't think we are at exactly in the same stage that we were 10 years ago in flue gas

cleaning. That would certainly be one way. Another way to go would be for the government just to do a holding action and try to help solve the specific problems that come up in the course of developing various processes or implementing them like the health research. I don't really think the government creates the problems, I think the government is the group with the social responsibility to help identify the problem and suggest social remedies for those problems, or remedies for those social problems. I tend to disagree with some of what you said there, but maybe that's one way that the government could go. Suppose I lay that out on the table, that's a way of being divisive. Maybe what the government should do is build a base line resource recovery system that's better than anything that's out there. What do you think of that? Do you want to try to comment? We should do this very quickly.

LAMB: I think [unintelligible] evaluate, it probably would succeed.

SJOBERG: Environmental, energy, and raw material national problems have created a resource recovery industry, and the government has to address itself to that problem. If you are going to have a resource recovery industry, the industry that is going to be there requires an incentive as established by the government. One of the things that the government has to address itself very diligently to, is what type of incentives are you going to provide the municipalities, for power companies, for companies like American Can if you stay in this business.

BERG: What incentives would you suggest?

SJOBERG: There are many. There are tax incentives; you have a whole spectrum of things.

BERG: Do you have a favorite though?

SJOBERG: Not specifically. I think here you have an open option because it's not only an incentive that's applicable to American Can, but there are incentives you have to apply to this municipality, to equipment vendors, whomever. This is the kind of thing that's going to be necessary to motivate this industry, because it takes money and it all can't be government money. We've invested a lot of money already, all major companies have; it takes a lot more, particularly if you are going to make it grow. A city with several major plants now in work and there are many, many millions of dollars invested in those, and for this industry to go there is going to have to be a tremendous amount of money invested. You have to provide incentives for us to do it, for the cities to do it, the states to do it, for the authorities to do.

WALTER: Well, I guess I should say that if we are not lying in our teeth that these systems are marginally economic, i.e., there will be an income to a city which will help reduce its cost of landfill, why should the Federal government provide money to do something that is going to make money? Well, I'm just being divisive also. Really we are saying these systems are not economic.

SJOBERG: Maybe they are marginal. Maybe in situations they are not economically feasible, but the environmental impacts require a mandate that we go in this direction. Every industry that goes into this is gambling and speculating on the cost of scrap, on the cost of fuel. It's a speculative business; there is no guarantee by the municipalities or the government, that we will get refunded for our investment.

WALTER: Well, I appreciate your comment and I was interested and pleased to receive and reinforce something that we've been saying, that the market is really not big enough to provide the incentive for business to go into these systems. That's really where it's at. The market is too small.

SJOBERG: Not too small, it's speculative. In fact, it may be too big and it takes too much money for any one company to go into it in a big way.

WALTER: Well, we would now have to spend a lot of time to define what terms we are using.

SJOBERG: This is right.

BERG: Before I move into the last part here, Art Purcell has another new name to throw into the sweepstakes. I'm not sure that I can pronounce it, Art. Chemacaficiation. To go back to the thing that I just touched on when I reviewed Session 3, it seems that perhaps the strongest recommendation to come out of the meeting is that we should have all people here and others that we may want to call in or who may volunteer become actively involved in cooperative work designed to develop methodologies and mechanisms for sharing technical information and compiling technical information, methodologies for data gathering and actually gathering the data. Am I misstating, Harvey?

ALTER: Close enough. Since this morning I have been talking to some of the participants, particularly George Trezek and Herb Hollander. I think a suitable mechanism for continuing this activity might be through the ASME and ASTM. I offer the good offices of the ASTM Committee to do this, and indeed we might even call or write you for a meeting on this subject during the next meeting of the E-38 Committee, which is the week of April 20 in Philadelphia. The committee can provide the meeting room, visual aids, the coffee, good fellowship, and there's no registration fee.

BERG: Are you tending to abandon the idea of the ad hoc committees to follow up on this meeting?

ALTER: Well, some people have convinced me, we need the umbrella of a professional-technical organization, to do this.

BERG: How do people react to that? I guess some of you expressed your opinions to Harvey. Does that seem to be the best way to go? O.K. Are there other recommendations that you'd like to make at this time?

SPENCER: I am a little disappointed in some of the comments I heard people say. It bothers me that there is no cohesive effort on the part of the government to do a lot of this work, and at the same time companies are going to invest a lot of money. I have to say that at least from where I sit (I'm not necessarily speaking for my company,) but at least as an individual, frankly, I don't think the field is developing as fast as I certainly thought it was going to. I know myself that if it were my money I would be a little bit hesitant to go after a lot of jobs where the cost of preparing requests for proposals is very high, the probability of proceeding with the given project is very low. Somebody in government ought to set the policies. I see dribbles of money going down lots of paths with much of it being wasted. I see that on the one hand we've got an employment problem, we've got public works funds that we are talking about, we've got money in ERDA, we've got money in the Navy, some at the Bureau of Mines, some in EPA, and it's all being done in a sort of small way, all being spent, but I'm not sure that it is being spent very effectively. It's very disappointing to me that there isn't any kind of a major effort like we had in other system development within the government, where the government takes a major step and really does something positive. I know that sounds kind of general, but frankly, I think you have to start with the general policy as to are we going to try to conserve our resources, conserve energy, employ people, and not pollute the environment. All of those things, if properly put together, can move the industry forward rapidly. What I see happening is a government effort, a congressional effort, whatever you want to call it, it is very disappointing. I see a lack of cohesiveness, a lot of small efforts being done, many of which I don't think have much value whatsoever to attacking the real problem, and an unwillingness to move the thing forward quickly. I'm sure that resource recovery will all take care of itself in due time. I'm sure that when it becomes economical that we will do additional things when we can see it beginning to pay off in short term. Meanwhile, as far as I can see, there are lots of other things that a company can invest in with a lot higher returns on the investment and a lot lower risk than resource recovery. As far as I can tell, a lot of these things don't make sense and it's not moving very quickly.

JOENSEN: I guess I would like to refine Mr. Spencer's comments, in that money for research and energy development really comes from Congress, and right now Congress is enthused with solar energy as a panacea of the country's problems, or solutions to the country's problems. I think somehow working through our Congress, which at least we are trying to do in Iowa, that resource recovery has to be really advertised more and given more emphasis. So when we talk about government funding, I think we've come back to Congress and not government agencies, because they submit budgets like everybody else and someone goes down and arbitrarily ticks off and strikes out line items. So we have to work through our members of Congress. They're the people who ultimately say where we should spend our money.

BERG: Are there any other recommendations people would like to bring up at this point?

RYDER: From our standpoint when we went to build our plant (somewhere around 20 million dollars), we thought perhaps this was an area that the Federal government would help us out on. However, we never did submit a formal request for a grant because we never got that far. We were told that funds were not available for a process that's already been demonstrated and that works and therefore "We're not going to help you build a plant. However if you experiment on something unproven, we'll be happy to work with you." Our plant was considered a scaled-up version of the St. Louis plant and therefore funds were not available because the initial idea had already been demonstrated. We had to float a bond issue to get the money for our own plant. I think maybe Chicago is one of the few cities perhaps that can do that. There are many, many cities that can't do that. This is where the Federal people ought to spend some money; more for ongoing processes. It appears that once the subject is researched nobody has money to put it into practice. In this report, if one has to choose, money for research should be minimal.

BERG: Let me just ask, Bill, one question. Suppose the government doesn't have enough money to do a demonstration grant in every city around the country, what percentage support or what other instrument would have been most useful in your eyes for the government to do?

RYDER: Well actually, if you are going to build a plant that is going to cost 20 million dollars, I would like to have had the Federal people give me 20 million dollars.

BERG: All right, short of that?

RYDER: It would depend on the circumstances. Chicago obviously was able to get by with nothing. Other communities have nothing, but would need the entire 20 million dollars or perhaps something in between.

SJOBERG: Loan guarantees and things of this nature where the government will guarantee the bonding of the municipalities which have a nebulous bonding capability is one way. There's many economic facets that you can take relative to this. I think one of the things we found is that there are divergent viewpoints between EPA and the energy people as to whether this is viable or not. I think somehow or other you have to attack not just that specific issue, but all of the different potential ways of doing it so that the government agencies, when the legislators come to you and ask you what do you recommend, you will at least have a concentrated effort behind it, realizing it's mandatory that you have some stand in order to get this industry off the dime. You can research all you want, but if the financing isn't there to make it move ahead, there will be no movement in the industry.

BERG: Then your preferred financing option would be bond guarantee?

SJOBERG: I don't know what it is, but it is one of the options. What I am saying is, though, there should be a uniform front between the government agencies that you've looked at. Then you can advise your legislators because they come to you. Because it's your bills that are put up--from ERDA and EPA.

WALTER: Just by a show of hands, how many of you feel that a loan or bond guarantee is valuable and useful to your city, assuming that it has any kind of thing on it you want, the bonds are still municipal bonds, they are still tax free, and anything else you want? How many of you think a loan guarantee is useful to you?

CHANTLAND: What's the interest rate?

WALTER: At whatever interest rate falls out. Presumably when you get the full faith and credit of the Federal government behind it, the interest rate is going to be fairly low, the low fives, maybe even the high fours. I see no hands from any city.

SPENCER: I don't think that loan guarantees are such a good idea. I think grants are great. In the case of Monroe County, the State chipped in 15 million dollars and sweetened the pot with an additional 6 to 8 million, which out of a 50 million dollar program, is a pretty good lump of money, probably more than the Federal government put out. I think that in terms of policy again, nobody has made the policy decision that we want to move in this direction and set the resources to do it quickly. Furthermore, I think that there's an attitude on the part of the agencies that this is a local problem, that it's not a Federal problem, and therefore it doesn't make sense to invest Federal dollars to solve a local problem. I think that you are now reaping what you have been preaching, and that's exactly right, now that you've said that there are no Federal dollars available to help municipalities in solving their problems. There is no question that the problem in one municipality, while the solution may be different, the problems are pretty much the same with respect to solid waste, and that there's some commonality and some savings that all communities can gain by a certain amount of Federal investment. When you are talking about dollars where the total Federal expenditure is less than what this one customer has to put out, the City of Chicago and Monroe County, New York, when the Federal level of investment is lower than one single project, what have you got?

ALTER: Listening to all this, I hear no return in the discussions to the demand-pull; what are we doing is pushing on a string. Consider for a moment--and I'm really putting this as a question, particularly to the utilities--what if there were a demand-pull such as being indemnified against damage to a boiler. Would this increase demand-pull? The utility says, all right, I can breathe easier now; the risk to my capital plant is insured. Now I want the fuel. Or is there some other demand-pull necessary, such as a favorable return on an investment, for using this material? Or both? Or a third factor? If then, the market was shored up some way, would not it be easier for a city to raise capital and wouldn't it be easier for the private sector to have a business?

FAY: I think there are some things that could be done. I have preached this to EPA every time they give me an opening, and that is all you got to

do is tell the utility that you will waive all initial limits if they fire garbage in that boiler, and I think you will have them beating off your door. Of course the reply is a lot of them ought to do that. Your point on indemnifying boiler risks, I think could ease a lot of the utilities into the position of accepting it easier than they will today. There are probably some other things, but as soon as you start saying that you're going to make money on this, it doesn't quite happen that way very easily due to fuel clauses and some of these other things. I don't think you really need to tell the utility they are going to make money on it, protect them from the risk.

RIGO: The reason that the Navy, actually DoD, is principally interested in solving a 100 ton a day problem, is they have a minor difficulty called garbage disposal. They don't have any place to put it on the bases, the surrounding community normally or frequently does not have a large garbage processor, they want nothing to do with your garbage, they've also got a problem called they've got to get rid of the garbage. At that point, whether it costs you \$5 a ton, or \$10, even \$15 a ton becomes quite immaterial. Now this is the situation that's developing nationwide. Landfills are being outlawed, incinerators are being shut down, something is going to have to be done. Economics may not be there for private industry today, but can anyone really say, especially near large urban areas, since Ohio won't let you landfill in their strip mines from the East Coast, there isn't going to be an incentive out there in the not too terribly distant future. We are looking at some really incredible tipping fees. They are beginning to out in Alameda, California. They are paying something like 23 dollars a ton to unload their garbage into a municipal system. Now with that kind of incentive, you can really get excited about doing something. Do we need any other incentive?

LAMB: I'm really against artificial stimulation by cash injection. I think grant programs consume lots of money and really show marginal benefits. This system won't work until it is the right thing to do, and when it is the right thing to do it will work fine, and we are pretty close to it being the right thing to do. So I'm very strongly against things like grant programs and demonstration programs and the building of large demonstration facilities. I really don't think they are necessary, and I think they are already too late. That is, there will be no useful data generated for the people who in the next two years will shake this thing out. So I think that tax credits or loan guarantees may be ways that may be necessary, I'm not even sure they are necessary. I really would like to strike a vote against large government, artificial stimulation of the market, with large government checks.

BERG: I want to say just one last thing. I think that there are quite a few people who deserve a vote of thanks. First of all, John Burckle, who put in the most work of all, I think, in organizing this whole thing, in getting in contact with you people; Midwest Research for putting together

that fine backup document; and the Franklins for all of their help and support here. Each of the session chairmen also deserve a hand with the possible exception of myself; and New Orleans has been an excellent host. In advance I'd like to thank NCRR for the trip to the facility tomorrow, and the City, and Waste Management. Most of all, I'd like to thank everybody who came, took the interest, and put in a good bit of work, I think. I appreciate it and I think everybody here deserves to applaud one another.

APPENDIX A

WORKSHOP ON

THE PREPARATION OF FUELS AND FEEDSTOCKS FROM MUNICIPAL SOLID WASTE

AGENDA

February 8	Assembly	9:00
	Welcome Address	9:05 - 9:15
	Ratification of Agenda	9:15 - 9:30
	SESSION 1: Systems Process Design	9:30 - 12:30
	Lunch Break	12:30 - 2:00
	SESSION 2: Selection of Equipment	2:05 - 6:00
February 9	Assembly	9:00
	SESSION 3: Technical Obstacles	9:05 - 12:30
	Lunch Break	12:30 - 2:00
	SESSION 4: Approach to R/D&D Programs	2:05 - 5:00
	SESSION 5: Summary and Conclusions	5:00 - 6:00
February 10	Assembly	8:15
	Departure	8:30
	Site Visit	9:15 - 12:00
	Expected Arrival at Airport	1:00

SESSION 1: Systems Process Design

Objective

The objective is to identify the critical aspects of process design and determine what information is needed to permit 1) more effective selection of systems and, 2) the design of more efficient systems.

Discussion

The following questions are considered of prime importance in judging the adequacy of our abilities to select and design preprocessing systems.

1. With the technology available today, can we produce a suitable product which the consumer considers a useful and desirable fuel? Are specifications for the fuel product available?
2. Is adequate information available to the implementor/investor for selection from competing commercial and developmental systems?
3. Is there an alternative process concept offering a potential of significant improvements in product quality, economic performance, or both over the present practice of primary shred and air classification?
4. Is adequate information available to the system supplier or consulting engineer to perform the process design with sufficient confidence to offer performance guarantees?

We suggest discussion of these issues with respect to the following topics:

- a. Product quality requirements and quality control, performance guarantees
- b. System reliability guarantees
- c. Selection and sequencing of unit operations, including interactions on product quality and cost
- d. Energy efficiency
- e. Economics, including the importance of materials recovery
- f. Ability to calculate adequate heat and material balances for process design
- g. Adequacy of present designs and information base for selection of competing systems

SESSION 2: Selection of Equipment

Objective

The objective is to identify the critical aspects of equipment selection and determine what additional information is needed for the selection process.

Discussion

Identify and discuss the adequacy of equipment and information for equipment selection when applied to refuse processing such as: 1) equipment performance data; 2) experience with existing equipment; 3) capital and operating (including maintenance) costs; 4) guarantees; 5) factors of scale (i.e., scale-up from research to full-scale systems; 6) effects of changes in incoming wastes, i.e., municipal, agricultural, and forestry; 7) large city vs. small town/rural applications. Where is there potential for improvements in equipment performance, and where are improvements most needed?

1. Waste receiving, storage and retrieval
2. Size reduction and size classification (hammermills, trommels, screens, etc.)
3. Light/heavy fraction separation (air classifiers)
4. Thermal and chemical treatment of cellulose for fuel production
5. Fuel densification (pellet mills, cubetters, briquetters)
6. Solids handling equipment
7. Fuel handling, storage, retrieval, and transport
8. Environmental control systems
9. Process control systems

SESSION 3: Technical Obstacles

Objective

The objective is to identify the technical areas of greatest need for research, development, and demonstration.

Discussion

Based upon the discussions in Sessions 1 and 2, the workshop members will prepare a listing of the research and development required to overcome technical barriers to implementation.

SESSION 4: Approach to Research, Development, and Demonstration Programs

Objective

The objective is to identify valid approaches to conducting R/D&D, to identify the appropriate role of the Federal government in sponsoring R/D&D, and to discuss the existing resources and capabilities of organizations conducting R/D&D.

Discussion

Given the R/D&D needs identified in Session 3, address the following aspects of past and future R/D&D programs:

1. The utility of information from government-sponsored R/D&D activities
2. The suitability of approaches for, a) process and equipment development and for, b) process and equipment performance evaluation considering the pilot plant, the field test of existing systems, development and demonstration of sub-systems at full or reduced scale, development and demonstration of a complete system integrated into a community solid waste management system
3. Capabilities of the private sector
 - a. NCRR pilot plant
 - b. Others
4. Capabilities of existing publicly-sponsored pilot plants
 - a. Bureau of Mines
 - b. University of California - Berkeley
 - c. Department of Defense (planned)
 - d. Department of Environment - Ontario
 - e. Warren Springs Laboratory - England
5. Potential for R/D&D with limited Federal action or support, considering rate of implementation, for four types of actions:
 - a. a regulatory program based upon environmental protection and resource conservation with no financial support
 - b. full-scale development and demonstration of systems integrated into the community waste management system
 - c. limited scale development and demonstration of subsystems
 - d. R/D support only

APPENDIX B

WORKSHOP
ON

THE PREPARATION OF FUEL AND FEEDSTOCKS
FROM MUNICIPAL SOLID WASTE

PARTICIPANTS

Dr. Harvey Alter
National Center for Resource Recovery
1211 Connecticut Avenue, N.W.
Washington, D.C. 20036

Mr. David Bendersky
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. David Berg - RD-681
401 M Street, S.W.
Washington, D.C. 20460

Mr. John Burckle
U.S. Environmental Protection Agency
26 West St. Clair Street
Cincinnati, Ohio 45268

Mr. Richard Bush
Vice President for Engineering & Operations
Connecticut Resources Recovery Authority
Hartford, Connecticut 06106

Mr. Peter J. Cambourelis
Raytheon Service Company
12 Second Avenue
Burlington, Massachusetts 01803

Mr. Arlie Capps
Stanford Research Institute
Menlo Park, California 94025

Mr. Arnold O. Chantland, P.E.
Public Works Department
City of Ames
Ames, Iowa 50010

Mr. G. C. Chisamore, P. Eng.
Manager, Program Development Section
Ontario Centre for Resource Recovery
Ministry of the Environment
4375 Chesswood Drive
Toronto, Ontario, M3J2C2, Canada

Mr. Roger S. De Cesare
College Park Metallurgy Research Center
Bureau of Mines
College Park, Maryland 20740

Mr. C. W. Fay
Wisconsin Electric Power Company
231 West Michigan Street
Milwaukee, Wisconsin 53201

Mr. Douglas E. Fiscus
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. William E. Franklin
Franklin Associates, Ltd.
8340 Mission Road - Suite 101
Prairie Village, Kansas 66206

Mrs. Marjorie A. Franklin
Franklin Associates, Ltd.
8340 Mission Road - Suite 101
Prairie Village, Kansas 66206

Mr. Harry Freeman
U.S. Environmental Protection Agency
5555 Ridge Avenue
Cincinnati, Ohio 45213

Mr. Robert Freeman
Stanford Research Institute
Menlo Park, California 94025

Mr. Harvey Funk
Henningson, Durham & Richardson
8404 Indian Hills Drive
Omaha, Nebraska 68114

Mr. Floyd Hasselriis
Combustion Equipment Associates, Inc.
555 Madison Avenue
New York, New York 10022

Mr. Steve Hathaway
Office of Chief Engineer
Department of the Army
DAEN-ROM
Washington, D.C. 20314

Mr. Herbert Hollander
Gilbert Associates
P.O. Box 1498
Reading, Pennsylvania 19603

Mr. Robert Holloway - AW-462
401 M Street, S.W.
Washington, D.C. 20460

Mr. Steve Hurley
U.S. Navy
Facilities Engineering Command
Alexandria, Virginia 22332

Dr. Alfred Joensen
Professor, Mechanical Engineering
Iowa State University
Ames, Iowa 50010

Mr. Dan Keyes
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Dr. Albert J. Klee
U.S. Environmental Protection Agency
26 West St. Clair Street
Cincinnati, Ohio 45268

Mr. Patrick J. Koloski, Secretary
Department of Sanitation
City Hall Room 2W13
1300 Perdido
New Orleans, Louisiana 70112

Mr. Ron Lalka
County Sanitation Districts of Los Angeles County
P.O. Box 4998
Whittier, California 90607

Mr. Tom Lamb
Arthur D. Little, Inc.
Acorn Park
Cambridge, Massachusetts 02104

Mr. Steven J. Levy - AW-462
401 M Street, S.W.
Washington, D.C. 20460

Mr. Stephan Lingle - AW-463
Chief, Technology & Markets Branch
401 M Street, S.W.
Washington, D.C. 20460

Mr. Robert A. Olexsey
Industrial Environmental Research Laboratory
26 West St. Clair Street
Cincinnati, Ohio 45268

Captain R. F. Olfenbuttel
Department of the Air Force
Pentagon, AF/PREVP
Washington, D.C. 20330

Dr. Thomas Padden - RD-682
401 M Street, S.W.
Washington, D.C. 20460

Mr. Bill Parker
National Center for Resource Recovery
1211 Connecticut Avenue, N.W.
Washington, D.C. 20036

Mr. Robert Powers
Recovery 1
17000 Chef Menteur Highway
New Orleans, Louisiana 70129

Dr. Arthur H. Purcell
Technical Information Project
1346 Connecticut Avenue, N.W., Suite 217
Washington, D.C. 20036

Dr. Greg Rigo
Systems Technology Corporation
245 North Valley Road
Xenia, Ohio 45385

Mr. William C. Ryder
Chief Environmental Design Engineer
Department of Engineering
City of Chicago
320 North Clark Street
Chicago, Illinois 60610

Mr. M. P. Schrag
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. F. E. Wisely
Horner & Shifrin, Inc.
5200 Oakland Avenue
St. Louis, Missouri 63110

Dr. L. T. Shannon
Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

Mr. H. T. D. Sjoberg
Americology
American Can Company
American Lane
Greenwich, Connecticut 06830

Dr. James E. Smith, Jr.
Environmental Research Center
U.S. Environmental Protection Agency
Technology Transfer
26 West St. Clair Street
Cincinnati, Ohio 45268

Mr. David Spencer
Raytheon Service Company
12 Second Avenue
Burlington, Massachusetts 01803

Dr. George J. Trezek, M.E.
College of Engineering
University of California
Berkeley, California 94720

Mr. Donald K. Walter
Chief, Urban Waste Technology Branch
Office of Conservation
Energy Research and Development Administration
Washington, D.C. 20545

Mr. Peter J. Ware
Occidental Research Corporation
1855 Carrion Road
La Verne, California 91750

Mr. Carlton Wiles
U.S. Environmental Protection Agency
26 West St. Clair Street
Cincinnati, Ohio 45268